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(INSTITUTED FEBRUARY 3, 1876.)

WITH A SEPARATELY-PAGED APPENDIX OF
MINERALOGICAL ABSTRACTS

EDITED BY L. J. SPENCER, F.R.S.

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PROSPECTUSES ON APPLICATION

MINERALOGICAL SOCIETY.

(*Instituted February 3, 1876.*)

BYE-LAWS.*

1. The object of the Mineralogical Society of Great Britain and Ireland, with which the Crystallogical Society was amalgamated on December 11, 1883, shall be to advance the knowledge of Mineralogy and also of Crystallography and Petrology.

2. The Society shall consist of Ordinary Members and Honorary Members.

ORDINARY MEMBERS.

3. Every candidate for Ordinary Membership shall be proposed by two Ordinary Members, one, at least, of whom shall have personal knowledge of the candidate.

4. Elections to Ordinary Membership shall be made by the Council, and shall be confirmed at the ensuing general meeting by a majority consisting of three-fourths of the Members present and voting.

5. Ordinary Members shall pay an entrance fee of one guinea and an annual subscription of one guinea. Ordinary Members elected on or before November 13, 1900, shall be entitled to compound for the annual subscription by a single payment of ten guineas: Ordinary Members elected after that date shall be entitled to compound for the annual subscription by a single payment of fifteen guineas.

6. Annual Subscriptions shall be due on the first of January of each year, but Members elected after the first of October shall not be required to pay a subscription for the then current year.

7. The name of any Ordinary Member whose subscription is more than two years in arrear shall be brought before the Council, and an intimation that this action has been taken shall be communicated to the Member. After the expiration of at least one year from that date, the Council shall be empowered to erase the name from the List of Members.

* Adopted at the Anniversary Meeting of November 13, 1900, and modified November 18, 1902, and November 7, 1916.

HONORARY MEMBERS.

8. Twenty persons, non-resident in the United Kingdom, may be elected Honorary Members. They shall pay neither entrance fee nor annual subscription.

9. Every candidate for Honorary Membership shall be proposed by two Members of the Council, and the election shall be by the Council, and shall be confirmed at the ensuing general meeting by a majority consisting of three-fourths of the Members present and voting.

COUNCIL.

10. The Society shall be governed by a Council, consisting of a President, two Vice-Presidents, a General Secretary, a Foreign Secretary, a Treasurer, an Editor of the Journal, and twelve Ordinary Members.

11. All members of the Society who have served the office of President shall be life-members of the Council.

11 *a*. The Trustees of the Society shall be *ex officio* members of the Council.

12. The Council shall be elected annually at the Anniversary Meeting.

13. Four Ordinary Members of Council shall retire annually, and shall not be eligible for re-election until the next Anniversary Meeting.

14. The Council shall prepare a List of Members nominated for election as Officers and Ordinary Members of Council.

15. The election of Council shall be effected by the agency of voting papers containing the List nominated by the Council. They shall be sent by the General Secretary, at least four weeks before the Anniversary Meeting, to every Ordinary Member of the Society, and every such Member shall be entitled to substitute the names of any other Ordinary Members of the Society for those on the List.

16. The voting papers shall be returned by the Members to the General Secretary, and shall be examined at the Anniversary Meeting by two Scrutineers appointed by the Chairman, who shall on their report declare the result of the election. The voting papers need not be signed.

17. The Council shall have power to appoint Officers, and to co-opt Ordinary Members of Council, to fill vacancies in the Council caused by death or resignation during the interval between two Anniversary Meetings.

18. Meetings of the Council shall be summoned by order of the President or the Council; at such meetings three shall be a quorum, of whom

one shall be either the President, a Vice-President, the Treasurer, or the General Secretary.

19. A Report of Council on the work and progress of the Society shall be submitted to each Anniversary Meeting

TRUSTEES.

20. Two or more Trustees shall be appointed by the Council, and the invested property of the Society shall stand in their names.

21. Composition-fees shall be treated as Capital: a Resolution of the Society at a general meeting, summoned with notice of a proposed disposition of property, shall be sufficient authority to the Trustees to give effect to such disposition; provided that a resolution of the Council shall be sufficient authority for any change of investment.

MEETINGS.

22. Meetings of the Society shall be summoned from time to time as may be deemed necessary by the Council, or at the requisition of any ten Members of the Society. One of these meetings in each year shall be termed the Anniversary Meeting.

JOURNAL.

23. The Numbers of the *Mineralogical Magazine and Journal of the Society* shall be issued at such intervals as the Council shall determine, and shall be sent, postage paid, to every Member of the Society.

AUDITORS AND BALANCE SHEET.

24. Two Ordinary Members of the Society, one of whom is not a Member of the Council, shall be appointed annually by the Council to audit the accounts of the Society.

25. No auditor shall serve for more than three years in succession.

26. The audited Balance Sheet, after submission to the Council, shall be published in the Journal of the Society as early as possible in every year.

EXPULSION OF MEMBERS.

27. A majority consisting of three-fourths of the whole Council shall have power to expel a Member from the Society, but a Member who

has been expelled shall have a right of appeal to the Society. Notice of such appeal to the Society shall be sent by such Member to the General Secretary within four weeks of the expulsion, and the appeal shall be considered by the Society at the next Anniversary Meeting; a majority of the votes recorded at such Meeting sufficing to confirm or annul the decision of the Council.

ALTERATION OF THE BYE-LAWS.

28. The Bye-laws may be altered only at an Anniversary Meeting, and only by a majority consisting of three-fourths of the Members present and voting. Notice of changes proposed to be made in the Bye-laws shall be communicated by the General Secretary to every Ordinary Member of the Society at least four weeks before the Anniversary Meeting at which they are to be considered.

OBLIGATION BOOK.

29. Ordinary Members, by payment of their entrance fee, signify their acceptance of any Bye-laws approved by the Society; and every Member of the Society shall sign an Obligation Book.

LIST OF MEMBERS.

(February, 1926.)

HONORARY MEMBERS.

- | Year of
Election. | |
|----------------------|---|
| 1905 | BAUMHAUER, Heinrich. Formerly Professor of Mineralogy in the University of <i>Freiburg, Switzerland.</i> |
| 1909 | BECKE, Friedrich Johann. Professor of Mineralogy and Petrography in the University of <i>Vienna.</i> |
| 1895 | BRÖGGER, Waldemar Christofer. <i>The University, Oslo, Norway.</i> |
| 1909 | CESÀRO, Giuseppe. Emeritus Professor of Mineralogy in the University of <i>Liège.</i> |
| 1913 | CLARKE, Frank Wigglesworth. Chief Chemist, <i>United States Geological Survey, Washington, D.C., U.S.A.</i> |
| 1897 | DANA, Edward Salisbury. Yale University, <i>New Haven, Conn., U.S.A.</i> |
| 1912 | GOLDSCHMIDT, Victor. Professor of Mineralogy in the University of Heidelberg. <i>9 Gaisbergstrasse, Heidelberg.</i> |
| 1877 | GROTH, Paul Heinrich von. Formerly Professor of Mineralogy in the University of Munich. <i>Alte Akademie, 51 Neuhauserstrasse, München.</i> |
| 1900 | LACROIX, Antoine François Alfred. Professor of Mineralogy in the Muséum National d'Histoire Naturelle. <i>61 Rue de Buffon, Paris, V.</i> |
| 1879 | TSCHERMAK, Gustav von. <i>The University, Vienna.</i> |
| 1912 | VIOLA, Carlo Maria. Professor of Mineralogy in the University of Parma. <i>35 Via Farnese, Parma, Italy.</i> |
| 1913 | WALLERANT, Frédéric. Professor of Mineralogy in the University, <i>Laboratoires à la Sorbonne, Paris.</i> |

ORDINARY MEMBERS.¹

A Annual Subscribers.

L Life-Members.

C Belonged to the Crystallogological Society at the time of the amalgamation of the two Societies, December 11, 1883.

Year of
Election.

- A 1922 ARKELL, Daniel John, B.Sc., F.C.S. *St. Edmund's College, Old Hall, Ware, Herts.*
- L 1900 ASHCROFT, Frederick Noel, M.A., F.C.S., F.G.S., F.R.G.S. *1 Egerton Gardens, South Kensington, London, S.W. 3.*
- A 1881 BAKER, Harry, F.I.C., F.C.S. '*Beacon Field*', *Weston Road, Runcorn, Cheshire.*
- A 1922 BALSILLIE, David, B.Sc., F.G.S., F.R.S.E. *Geological Dept., Royal Scottish Museum, Edinburgh.*
- A 1918 BARBASON, François. *Cia. Belga de Minas de Linares, Jaén, Spain.*
- A 1904 BARKER, Thomas Vipond, M.A., B.Sc. (Oxon.), F.C.S. *Department of Mineralogy, University Museum, Oxford.*
- L 1894 BARLOW, William, F.R.S. *The Red House, Stanmore, Middlesex.*
- A 1913 BARRETO, Dr. Antonio de Barros. Professor of Mineralogy and Geology in the Polytechnic School of São Paulo. *Rua Maranhão 60, Hygienopolis, São Paulo, Brazil.*
- L 1893 BARROW, George, F.G.S., M.I.M.M. Formerly of the Geological Survey of England. *202 Brecknock Road, London, N. 19.*
- A 1922 BELAIEW, Nicholas Timothy, Colonel, C.B., M.I.M.E. *33 Elvaston Place, Queen's Gate, London, S.W. 7.*
- L 1912 BELL, Robert. *64 Newington Avenue, Belfast.*
- L 1888 BEMROSE, Henry Howe, J.P., M.A., Sc.D., F.G.S. *Ash Tree House, Osmaston Road, Derby.*
- A 1906 BLAKE, George Stanfield, B.Sc., A.R.S.M., F.C.S., F.G.S. Geological Survey of Palestine. *P.O. Box 356, Jerusalem, Palestine.*
- A 1923 BLUMENTHAL, Maurice. *558 Quincy Street, Brooklyn, New York, U.S.A.*

¹ Corrections for this List should be sent to the General Secretary.

	Year of Election.	
A	1922	BOSWELL, Percy George Hamnall, O.B.E., D.Sc., A.R.C.S., F.G.S. Professor of Geology, The University, Liverpool. <i>'Alsager', Lyndhurst Road, Wallasey, Cheshire.</i>
L	1897	BOWMAN, Herbert Lister, M.A., D.Sc., F.G.S., F.C.S. Professor of Mineralogy in the University of Oxford. <i>Department of Mineralogy, University Museum, Oxford.</i>
A	1923	BRADY, Oscar Lisle, B.A., D.Sc., F.I.C. <i>University College Club, 21 Gower Street, W.C. 1.</i>
A	1923	BRAGG, Sir William Henry, K.B.E., M.A., D.Sc., F.R.S., Director of the Royal Institution. <i>21 Albemarle Street, London, W. 1.</i>
A	1920	BRAGG, William Lawrence, O.B.E., M.A., F.R.S. Professor of Physics. <i>The University, Manchester.</i>
A	1919	BRAMMALL, Alfred, Ph.D., M.Sc., D.I.C., F.G.S., A.I.M.M. <i>Dept. of Geology, Imperial College of Science and Technology, South Kensington, London, S.W. 7.</i>
A	1922	BROADHEAD, James. <i>15 Langholm Crescent, Darlington, Co. Durham.</i>
A	1923	BUCKLEY, Harold Eugene, M.Sc. <i>273 Wigan Road, Bolton, Lancashire.</i>
A	1921	BULL, Alfred Joseph, M.Sc., F.Inst.P., F.G.S. <i>L.C.C. School of Photo-engraving, 6 Bolt Court, Fleet Street, London, E.C. 4.</i>
L	1885	BUTLER, Francis Henry, M.A., A.R.S.M., L.S.A. (Lond.). <i>158 Brompton Road, London, S.W. 3.</i>
A	1919	BUTTGEBACH, Henri Jean François. Professor of Crystallography and Mineralogy in the University of Liège. <i>439 Avenue Louise, Bruxelles, Belgium.</i>
A	1923	CAHN, Lazard. <i>6 North Eighth Street, Colorado Springs, Colorado, U.S.A.</i>
A	1924	CAMPBELL, Robert, M.A., D.Sc., F.G.S., F.R.S.E., Lecturer in Petrology, University of Edinburgh. <i>'Martyton', Woodhall Road, Colinton, Edinburgh.</i>
A	1913	COLLINGRIDGE, Harvey, B.Sc., F.G.S., A.M.I.C.E. <i>Ash Cottage, Harrow Drive, Romford, Essex.</i>
L	1923	COMBE, Arthur Delmar, F.G.S. <i>Geological Survey, Entebbe, Uganda, East Africa.</i>

- | | Year of
Election. | |
|---|----------------------|--|
| L | 1900 | COOMARASWAMY, Ananda K., D.Sc., F.L.S., F.G.S., M.R.A.S.
Keeper of Indian Art, <i>Museum of Fine Arts, Boston,
Mass., U.S.A.</i> |
| A | 1924 | COUSSMAKER, Arthur Blakeney, M.C., F.G.S., A.I.M.M. 78
<i>Hatton Garden, London, E.C. 1.</i> |
| A | 1907 | CROOK, Thomas, A.R.C.Sc.I., F.G.S. <i>Mineral Resources Dept.,
Imperial Institute, South Kensington, London, S.W. 7.</i> |
| A | 1899 | CULLIS, Charles Gilbert, D.Sc., F.G.S. Professor of Economic
Mineralogy in the <i>Imperial College of Science and Technology,
South Kensington, London, S.W. 7.</i> |
| L | 1899 | CURRIE, James, M.A., F.R.S.E. <i>Larkfield, Golden Acre,
Edinburgh.</i> |
| A | 1926 | DAVIES, George MacDonald, M.Sc., F.G.S. Lecturer in
Geology, Birkbeck College, London. 104 <i>Avondale Road,
South Croydon, Surrey.</i> |
| L | 1885 | DAW, John Williams, M.I.M.M. c/o <i>Akoko Main Reef Ltd.,
Akoko Camp, Tarkwa, Gold Coast Colony, West Africa.</i> |
| L | 1898 | DE CASTRO, John Paul, M.A., F.C.S., F.I.C. 1 <i>Essex Court,
Temple, London, E.C. 4.</i> |
| A | 1925 | DEWEY, Henry, F.G.S. Geological Survey of England, 28
<i>Jermyn Street, London, S.W. 1.</i> |
| A | 1925 | DOUBLE, Ivan Sidney, M.Sc., F.G.S. <i>Geological Dept., The
University, Liverpool.</i> |
| L | 1910 | DRUGMAN, Julien Léon Eugène, Ph.D., M.Sc., F.C.S. 33 <i>Rue
Edmond Picard, Uccle, Bruxelles, Belgium.</i> |
| A | 1925 | DWERRYHOUSE, Arthur Richard, D.Sc., F.G.S., M.R.I.A.
16 <i>Darell Road, Caversham, Oxfordshire.</i> |
| L | 1918 | EDGE, Arthur Broughton, M.B.E., A.R.S.M., A.R.C.S., B.Sc.,
F.C.S., F.G.S. c/o <i>Royal School of Mines, South Ken-
sington, London, S.W. 7.</i> |
| A | 1925 | ELLSWORTH, Hardy Vincent, M.A., Ph.D. <i>Geological Survey
of Canada, Ottawa, Canada.</i> |
| A | 1919 | ELSDEN, James Vincent, D.Sc., F.G.S. 14 <i>St. Saviour's
Road, St. Leonards-on-Sea, Sussex.</i> |
| A | 1920 | ENGLISH, George Letchworth. 50 <i>Brighton Street, Rochester,
New York, U.S.A.</i> |
| L | 1891 | EVANS, John William, C.B.E., LL.B., D.Sc., F.R.S. Lecturer
in Petrology, Imperial College of Science and Technology.
121 <i>Harley Street, London, W. 1.</i> |

Year of
Election.

- A 1924 FABRY, Richard John Charles, A.R.C.S., B.Sc. 19 *Barnard Hill, Muswell Hill, London, N. 10.*
- A 1915 FERMOR, Lewis Leigh, O.B.E., A.R.S.M., D.Sc., F.G.S. Superintendent, *Geological Survey of India, Calcutta.*
- A 1920 FERRAZ, Jorge Belmiro de Araujo. *Praia da Saudade 116, Rio de Janeiro, Brazil.*
- L 1895 FLETCHER, Rev. Mark, M.A., M.Sc., F.G.S. Lecturer in Mineralogy in the Armstrong College, Newcastle-on-Tyne. *Long Benton Vicarage, Forest Hall, Northumberland.*
- L 1902 FLETT, Sir John Smith, K.B.E., M.A., LL.D., D.Sc., F.R.S. Director of the Geological Survey of Great Britain. 28 *Jermyn Street, London, S.W. 1.*
- A 1926 FORD, Hugh Alexander, H.B.M. Consul. *The British Consulate, Colon, Panama.*
- A 1923 GARNETT, Cecil Stevenson, F.C.S., F.G.S. 25 *Crompton Street, Derby.*
- L 1902 GILES, William Brantingham, F.I.C. *The Grange, Leyton, Essex.*
- L 1886 GOLDSCHMIDT, Victor, Ph.D., Professor of Mineralogy in the University of Heidelberg. 9 *Gaisbergstrasse, Heidelberg, Germany.*
- A 1905 GOODCHILD, Wilbert, M.B., Ch.B. (Edin.). *Blencathra Sanatorium, Threlkeld, Penrith, Cumberland.*
- A 1922 GORDON, Hugh Septimus, M.I.M.M., F.G.S. 10 *Nevill's Court, Fetter Lane, London, E.C. 4.*
- A 1923 GORDON, Samuel George. *Academy of Natural Sciences, Logan Square, Philadelphia, Pa., U.S.A.*
- A 1923 GORDON, William Thomas, M.A., D.Sc., F.R.S.E., F.G.S., Professor of Geology, *King's College, Strand, London, W.C. 2.*
- A 1903 GRABHAM, George Walter, M.A., F.G.S. Geologist to the Sudan Government. *P.O. Box 178, Khartum, Sudan.*
- A 1913 GRAHAM, Richard Percival Devereux, B.A. (Oxon). Assistant Professor of Mineralogy, *McGill University, Montreal, Canada.*
- A 1924 GRANTHAM, Donald Robert, A.R.S.M., A.R.C.S., B.Sc. *Imperial College of Science and Technology, South Kensington, London, S.W. 7; and 77 Wolfington Road, West Norwood, S.E. 27.*

- Year of
Election.
- A 1923 GREENWOOD, Gilbert, M.Sc., F.C.S. *Thorn Bank, Edenfield, Manchester.*
- A 1921 GREGORY, Albert George Frederick. 139 *Fulham Road, London, S.W. 3.*
- L 1892 GREGORY, John Walter, D.Sc., F.R.S. Professor of Geology in the *University of Glasgow.*
- A 1911 HALL, Thomas Clifford Fitzwilliam, F.G.S., M.I.M.M. *Trevu, Camborne, Cornwall; and 20 Copthall Avenue, London, E.C. 2.*
- A 1912 HALLIMOND, Arthur Francis, M.A., F.G.S. Assistant Curator, *Museum of Practical Geology, 28 Jermyn Street, London, S.W. 1.*
- A 1885 HARKER, Alfred, M.A., LL.D., F.R.S. University Reader in Petrology. *St. John's College, Cambridge.*
- L 1900 HARTLEY, Harold Brewer, M.C., C.B.E., M.A., F.C.S. *Balliol College, Oxford.*
- A 1917 HARWOOD, Henry Francis, M.Sc., Ph.D., A.I.C. Lecturer in Chemistry, *Imperial College of Science and Technology, South Kensington, London, S.W. 7.*
- A 1910 HATCH, Frederick Henry, O.B.E., Ph.D., M.I.M.M., F.G.S. *Mines Department, Dean Stanley Street, Westminster, London, S.W. 1.*
- A 1921 HAWKES, Leonard, M.Sc., F.G.S. Reader in Geology, University of London. *Bedford College, Regent's Park, London, N.W. 1.*
- L 1879 HENSON, Samuel. 4 *Elliott House, Elliott Road, Thornton Heath, Surrey.*
- L 1907 HILTON, Harold, M.A., D.Sc. Professor of Mathematics in the University of London. *Bedford College, Regent's Park, London, N.W. 1.*
- L 1896 HOLLAND, Sir Thomas Henry, K.C.S.I., K.C.I.E., A.R.C.S., D.Sc., F.R.S. Rector in the Imperial College of Science and Technology. 6 *Wetherby Gardens, London, S.W. 5.*
- A 1914 HOLMES, Arthur, D.Sc., D.I.C., A.R.C.S., F.G.S. Reader in Geology, *The University, Durham.*
- A 1908 HOPKINS, Edward. 32-34 *Holborn Viaduct, London, E.C. 1.*
- A 1925 HORN, Aubrey Evelyn, *Loup House, Axminster, Devon; and c/o Naraguta (Nigeria) Tin Mines, Ltd., P.O. Jos, Northern Nigeria.*

Year of
Election.

- A 1902 HOWE, John Allen, O.B.E., B.Sc., F.G.S. Assistant to the Director, Geological Survey of Great Britain. 28 *Jermyn Street, London, S.W. 1.*
- L 1890 HUTCHINSON, Arthur, O.B.E., M.A., Ph.D., F.R.S., Lecturer in Crystallography and Demonstrator in Mineralogy in the University of Cambridge, *Pembroke College, Cambridge.*
- A 1923 JARDINE, Irvine George, B.Sc., F.G.S. 27 *Cecil Road, Upton Manor, London, E. 13.*
- A 1920 JOHNSON, Edward Lionel, M.Sc., F.G.S. *Ashfield, Castleton, Yorkshire.*
- A 1925 JOHNSTON, Robert Angus Alister, F.R.S.C. 197 *Bronson Avenue, Ottawa, Ontario, Canada.*
- L 1905 JONES, Bernard Mouat, D.S.O., M.A., F.C.S. Principal of *The College of Technology, Manchester.*
- L 1908 JONES, Owen Thomas, M.A., D.Sc., F.G.S. Professor of Geology, *The University, Manchester.*
- A 1917 KITSON, Albert Ernest, C.M.G., C.B.E., F.G.S. Director of the Geological Survey of the Gold Coast. 29 *Alfred Place, South Kensington, London, S.W. 7.*
- L 1876 KITTO, Benedict, F.I.C., F.G.S. 26 *Lancaster Road, Finsbury Park, London, N. 4.*
- A 1885 KUNZ, George Frederick, M.A., Ph.D., Sc.D., F.G.S. 405 *Fifth Avenue, New York City, U.S.A.*
- A 1922 LAKE, Harry William, Colonel, C.M.G., M.I.M.M. 26 *Bolton Gardens, London, S.W. 5; and 5 Broad Street Avenue, Blomfield Street, London, E.C. 2.*
- A 1924 LANE, Alfred Church, A.B., Ph.D., Sc.D. Professor of Geology, *Tufts College, Massachusetts, U.S.A.*
- A 1923 LARSEN, Esper Signius, Ph.D. Professor of Petrology, *Harvard University, Cambridge, Mass., U.S.A.*
- A 1923 LEECH, John George Chambré, A.R.S.M. 7 *Belvedere Grove, Wimbledon, London, S.W. 19.*
- A C LEWIS, William James, M.A., F.R.S., Professor of Mineralogy in the University of Cambridge. *The New Museums, Cambridge.*
- L 1876 LIVERSIDGE, Archibald, M.A., A.R.S.M., LL.D., F.R.S. Formerly Professor of Chemistry in the University of Sydney, New South Wales. '*Fieldhead*', *George Road, Coombe Warren, Kingston, Surrey.*

- | | Year of
Election. | |
|---|----------------------|---|
| A | 1879 | LOUIS, Henry, M.A., D.Sc., A.R.S.M., F.G.S. Professor of Mining in the <i>Armstrong College, Newcastle-on-Tyne</i> . |
| A | 1925 | LUMB, Arthur Douglas, M.C., A.R.S.M., F.G.S., M.I.M.M., F.R.G.S. 47 <i>Putney Hill, London, S.W.</i> 15. |
| A | 1910 | MACALISTER, Donald Alexander, A.R.S.M., F.G.S. 10 <i>St. Alban's Road, Kensington, London, W.</i> 8. |
| A | 1914 | MACGREGOR, Alexander Miers, B.A., F.G.S. Geological Survey of Southern Rhodesia. <i>P.O. Box 366, Salisbury, Rhodesia</i> . |
| A | 1919 | McINTYRE, William Angus, A.R.C.S., B.Sc., F.G.S. 94 <i>Amyand Park Road, Twickenham, Middlesex</i> . |
| A | 1925 | MACLAREN, James Malcolm, D.Sc., F.G.S. <i>Burncoose, Gwennap, Redruth, Cornwall</i> ; and <i>Royal Colonial Institute, Northumberland Avenue, London, S.W.</i> 1. |
| A | 1908 | McLINTOCK, William Francis Porter, D.Sc., F.G.S. Curator of the <i>Museum of Practical Geology, 28 Jermyn Street, S.W.</i> 1. |
| A | 1921 | McROBERT, Lady Rachel Workman, B.Sc., F.G.S. <i>Doune-side, Tarland, Aboyne, Aberdeenshire</i> . |
| A | 1925 | MARSHALL, Patrick, M.A., D.Sc., F.G.S. <i>Bellevue Road, Lower Hutt, Wellington, New Zealand</i> . |
| L | 1919 | MELMORE, Sidney, F.Sc., F.G.S. ' <i>Winkinghurst, Carr Lane, Acomb, York</i> . |
| A | 1902 | MENNELL, Frederic Philip, F.G.S. <i>P.O. Box 490, Bulawayo, Rhodesia, South Africa</i> . |
| A | 1923 | MERWIN, Herbert Eugene, Ph.D. <i>Geophysical Laboratory, 2801 Upton Street, Washington, D.C., U.S.A.</i> |
| L | C | MIERS, Sir Henry Alexander, Kt., M.A., D.Sc., Hon. LL.D. (Michigan and Liverpool), F.R.S. Vice-Chancellor of the University of Manchester. <i>Birch Heys, Cromwell Range, Fallowfield, Manchester</i> . |
| A | 1923 | MILNER, Henry Brewer, M.A., F.G.S. 4 <i>Wycombe Gardens, Golders Green, London, N.W.</i> 11. |
| A | 1921 | MITCHELL, Allan Ernest, B.Sc., F.C.S. <i>Norton Hall, Norton-on-Tees, Co. Durham</i> . |
| A | 1912 | MORGAN, Arthur Henry, A.M.I.C.E., M.I.M.M. Superintendent of the <i>Ruby Mines, Mogok, Upper Burma</i> . |
| L | 1922 | MOUNTAIN, Edgar Donald, M.A. <i>British Museum (Natural History), Cromwell Road, London, S.W.</i> 7. |

- Year of
Election.
- A 1924 MURRAY-HUGHES, Robert, F.G.S. *P.O. Lusaka, Northern Rhodesia.*
- L 1920 ÔHASHI, Ryôichi. Professor of Geology and Mineralogy, *Akita Mining College, Akita, Japan.*
- A 1922 PARKER, Robert Luling, Ph.D. *Mineralogical Institute, Sonneggstrasse 5, Zürich 6, Switzerland.*
- A 1915 PARSONS, Arthur Leonard. Assistant-Professor of Mineralogy, *University of Toronto, Canada.*
- L 1880 PEARCE, Richard, Ph.D., F.G.S. *11 Phillimore Gardens, London, W. 8.*
- A 1923 PHEMISTER, James, M.A., B.Sc., F.G.S. *Geological Survey of Scotland, 33 George Square, Edinburgh.*
- A 1922 PILLAI, Cumbakonam Kailasa Krishnaswami, M.A. Professor of Geology, *Presidency College, Madras, India.*
- L 1899 POLLARD, William, M.A., D.Sc., F.G.S., F.C.S. *Oakfield, Hitchin, Hertfordshire.*
- A 1891 POPE, Sir William Jackson, K.B.E., M.A., M.Sc., D.Sc., LL.D., F.R.S. Professor of Chemistry in the University of Cambridge. *Holmesdale, Brooklands Avenue, Cambridge.*
- A 1910 PORTER, Miss Mary Winearls, B.Sc. *6 Tackley Place, Oxford.*
- L 1887 PRIOR, George Thurland, M.A., D.Sc., F.R.S. Keeper of Mineral Department in the *British Museum (Natural History), Cromwell Road, London, S.W. 7.*
- A 1922 PUCKLE, Geoffrey Montagu. *Swallowfield Park, Reading, Berks.*
- L 1908 RAISIN, Miss Catherine Alice, D.Sc., F.L.S., F.G.S. *15 Leinster Gardens, London, W. 2.*
- A 1903 RASTALL, Robert Heron, M.A., Sc.D., F.G.S., M.I.M.M. *Christ's College, Cambridge.*
- A 1923 READ, Herbert Harold, D.Sc., A.R.C.S., F.G.S. *Geological Survey of Scotland, 33 George Square, Edinburgh.*
- A 1922 REEKIE, John, B.A. *Burnham, Brooklands, Brookbourne, Herts.*
- A 1915 RICHARDSON, William Alfred, D.Sc., B.A., B.Sc. (Engin.), F.G.S. Lecturer in Petrology, *University College, Nottingham.*
- A 1919 ROBERTS, Malcolm, A.R.S.M., M.I.M.M. *Cie. Aramayo de Mines en Bolivie, Quechisla, Bolivia, South America.*

Year of
Election.

- A 1914 ROGERS, Arthur William, M.A., Sc.D., F.R.S. Director of the Geological Survey of the Union of South Africa, *P.O. Box 401, Pretoria, Transvaal, South Africa.*
- A 1913 ROGERS, Austin Flint, A.M., Ph.D. Associate Professor of Mineralogy and Petrography, *Leland Stanford Junior University, Palo Alto, California, U.S.A.*
- A 1902 RUSSELL, Arthur Edward Ian Montagu, M.B.E. *Swallowfield Park, Reading, Berks.*
- A 1918 SANDISON, William Greswolde Williams. *Kilda, Baltasound, Unst, Shetland.*
- A 1912 SCHALLER, Waldemar Theodore, Ph.D. *United States Geological Survey, Washington, D.C., U.S.A.*
- A 1919 SCHOELLER, Walter Raymond, Ph.D., A.I.M.M., A.I.C. '*Purbeck*', *Great Missenden, Bucks.*
- A 1920 SCHOEP, Alfred, D.Sc. Professor of Crystallography and Mineralogy in the University, *6 Rue de la Roseraie, Ghent, Belgium.*
- A 1914 SCOTT, Alexander, M.A., D.Sc. *Pottery Laboratory, Central School of Science and Technology, Stoke-on-Trent, Staffordshire.*
- A 1908 SHAND, Samuel James, D.Sc., Ph.D., F.G.S. Professor of Geology, *University of Stellenbosch, South Africa.*
- A 1919 SHEPPARD, George, B.Sc., F.G.S. *1 Elm Avenue, Garden Village, Hull, Yorkshire.*
- A 1912 SIMPSON, Edward Sydney, D.Sc., B.E., F.C.S. Government Mineralogist and Analyst, Western Australia. '*Carlingford*', *Mill Point, South Perth, Western Australia.*
- L 1897 SMITH, George Frederick Herbert, M.A., D.Sc., F.G.S., F.R.A.S. *British Museum (Natural History), Cromwell Road, London, S.W. 7.*
- A 1911 SMITH, Herbert Gladstone, B.Sc., A.R.C.S., F.G.S. Reader in Geology, *East London College, Mile End Road, London, E. 1.*
- L 1910 SMITH, Walter Campbell, M.C., M.A., F.G.S. *British Museum (Natural History), Cromwell Road, London, S.W. 7.*
- A 1925 SPENCER, Edmondson, Ph.D., B.Sc., A.R.S.M., F.I.C., F.G.S. *c/o Messrs. Bird & Co. (Research Dept.), Post Box 46, Calcutta, India.*

- Year of
Election.
- A 1894 SPENCER, Leonard James, M.A., Sc.D., F.R.S. *British Museum (Natural History), Cromwell Road, London, S.W. 7.*
- A 1923 STILLWELL, Frank Leslie, D.Sc. 44 *Elphin Grove, Hawthorne, Victoria, Australia.*
- A 1923 STOCKLEY, Gordon Murray, A.R.C.S., A.I.C., F.C.S. 17 *Maldon Road, Acton, London, W. 3.*
- A 1925 SWINTON, William Elgin, B.Sc., F.G.S., F.L.S., F.Z.S. Geological Dept., *British Museum (Natural History), Cromwell Road, London, S.W. 7.*
- A 1925 TARR, William Arthur, B.Sc., B.S., Ph.D. Professor of Geology and Mineralogy, *University of Missouri*; and 1316 *Ross Street, Columbia, Missouri, U.S.A.*
- A 1922 TAYLOR, Joseph Cornelius. 'Rodmersham', 7 *Albert Road, Hendon, London, N.W. 4.*
- A 1903 THOMAS, Herbert Henry, M.A., Sc.D., F.G.S. Petrographer to the Geological Survey of Great Britain. 28 *Jermyn Street, London, S.W. 1.*
- A 1921 TILLEY, Cecil Edgar, B.Sc., Ph.D., A.I.C., F.G.S. *Sedgwick Museum, Cambridge.*
- A 1925 TOMKEIEFF, Sergei Ivanovich. *Geology Dept., Armstrong College, Newcastle-on-Tyne.*
- A 1925 THOMSON, Ellis, B.A.Sc. Assistant-Professor, *Dept. of Mineralogy, University of Toronto, Canada.*
- A 1923 TSUBOI, Seitarō. *Geological Institute, College of Science, Imperial University, Tōkyō, Japan.*
- A 1921 TULLY, Bristow John, F.G.S., F.Z.S. 10 A *New Bond Street, London, W. 1.*
- L 1920 TUNBRIDGE, Edward William, B.Sc., F.G.S. 'Westbury', *Lillington, Leamington Spa, Warwickshire.*
- L 1891 TUTTON, Alfred Edwin Howard, M.A., D.Sc., F.R.S. 'Silbury', 60 *Grange Road, Cambridge.*
- A 1922 VAUX, George, Junr., S.B., LL.B. President of the Mineralogical Society of Philadelphia. *Gulf Road, Bryn Mawr, Pennsylvania, U.S.A.*
- A 1925 VENDL, Aladár, Ph.D. Professor in the Technical High School, *Vörösmarty utca 10/B, Budapest VII, Hungary.*
- A 1925 VENDL, Miklós, Ph.D. Professor of Mineralogy and Geology, *Mining Academy, Sopron, Hungary.*

- Year of
Election.
- A 1913 WALKER, Thomas Leonard, M.A., Ph.D., F.G.S. Director of the Royal Ontario Museum of Mineralogy, and Professor of Mineralogy and Petrography in the *University of Toronto, Canada.*
- A 1923 WASHINGTON, Henry Stephens, Ph.D. *Geophysical Laboratory, 2801 Upton Street, Washington, D.C., U.S.A.*
- A 1923 WATSON, John Adam, A.C.G.I., F.I.C., F.C.S. 22 *Polwarth Gardens, Edinburgh.*
- L 1894 WATTS, William Whitehead, M.A., M.Sc., Sc.D., LL.D., F.R.S. Professor of Geology in the *Imperial College of Science and Technology, South Kensington, London, S.W. 7.*
- L 1901 WESTON, Digby St. Aubyn P., Commander, Royal Navy (Retired). 79 *Onslow Gardens, London, London, S.W. 7.*
- A 1920 WHITE, Franklin, M.I.M.M. 19 *St. Swithin's Lane, London, E.C. 4.*
- A 1924 WHITLOCK, Herbert Percy. *American Museum of Natural History, Central Park, New York City, U.S.A.*
- A 1918 WILCOCKSON, William Howson, M.A., F.G.S. *Geological Dept., University of Sheffield.*
- L 1925 WILLIAMS, Alpheus Fuller, B.Sc. General Manager, De Peers Consolidated Mines, Ltd. *P.O. Box 616, Kimberley, South Africa.*
- A 1918 WILLIAMS, Arthur Stanley, M.I.M.M. 'Ellerslie', 4 *Russel Avenue, Hartley, Plymouth.*
- L 1876 WILLS, Joseph Lainson, F.C.S. *Chemists Buildings, 50 East 41st Street, New York City, U.S.A.*
- A 1923 WILSON, Norman Wrigley. *Imperial College Union, South Kensington, London, S.W. 7.*
- L C WOODWARD, Charles Josiah, B.Sc., F.G.S. 'The Lindens', *St. Mary's Road, Harborne, Birmingham.*
- A 1919 WORTH, Richard Hansford, M.Inst.C.E., F.G.S. 32 *Thornhill Road, Plymouth.*
- L 1923 WRIGHT, Frederic Eugene, Ph.D. *Geophysical Laboratory, 2801 Upton Street, Washington, D.C., U.S.A.*
- A 1921 ZUTSHI, Lambodhar, B.Sc. 21 *Cromwell Road, London, S.W. 7.*
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SOCIETIES, INSTITUTIONS, ETC.

To which the Publications of the Mineralogical Society are sent.

(Those sending Publications in Exchange are marked with an asterisk.)

LONDON: Royal Society, *Burlington House, W. 1.*

Geological Society „ „

*Geologists' Association, *University College, Gower Street, W.C. 1.*

*Imperial Institute, *South Kensington, S.W. 7.*

*Institution of Mining and Metallurgy, *Cleveland House, City Road, London, E.C. 1.*

LIVERPOOL: *Geological Society, *Royal Institution, Colquitt Street.*

EDINBURGH: Royal Society.

*Geological Society, *Synod Hall Buildings, Castle Terrace.*

GLASGOW: *Geological Society, *207 Bath Street.*

PARIS: *Société française de Minéralogie, *Sorbonne.*

BRUSSELS: Société belge de Géologie, de Paléontologie et d'Hydrologie.

LIÈGE: *Société géologique de Belgique.

ZÜRICH: *Zeitschrift für Kristallographie. (*Prof. P. Niggli, Mineralogical Institute, Sonneggstrasse 5, Zürich 6.*)

VIENNA: *Naturhistorisches Museum, *Burgring.*

UPSALA: *Kongl. Universitets-Biblioteket.

ROME: *Ufficio Geologico, *Via Sta. Susanna.*

NAPLES: *Società Reale, *Accademia delle Scienze Fisiche e Matematiche.*

PISA: *Società Toscana di Scienze Naturali.

SYDNEY: *Australian Museum.

WASHINGTON (D. C.): *United States Geological Survey.
Smithsonian Institution.

NEW HAVEN (Conn.): *American Journal of Science.

PROCEEDINGS

OF THE

MINERALOGICAL SOCIETY

EXCERPT MINUTES OF COUNCIL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., January 20, 1925, at 4.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

The deaths of Sir Archibald Geikie, one of the original members of the Society; Prof. G. D. Liveing, one of the members of the Crystallogical Society; and Mr. R. C. Webb were announced.

Mr. Henry Dewey, Prof. William Arthur Tarr, and Mr. Sergei Ivanovich Tomkeieff were provisionally elected Ordinary Members of the Society.

The balance-sheet and abstract of receipts and payments for the year ending December 31, 1924, were submitted and were approved subject to audit by Dr. Harwood and Mr. De Castro, who were appointed auditors. It was resolved that in future the auditors be appointed at the November meeting.

The Treasurer reported to the Council certain members whose subscriptions were in arrears; and he was instructed to take action in accordance with bye-law 7.

GENERAL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., January 20, 1925, at 5.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

Eighteen Members and four Visitors were present.

The elections of Messrs. H. Dewey, W. A. Tarr, and S. I. Tomkeieff were confirmed.

The following papers were read:—

1. An X-ray examination of calcium formate: by Miss K. Yardley (vol. 20, p. 296).

2. Afwillite, a new hydrous calcium silicate, from Dutoitspan mine, Kimberley, South Africa: by Mr. John Parry and Dr. F. E. Wright (vol. 20, p. 277).

3. On tyuyamunite from the Tyuya-Muyun radium mine, Fergana: by Prof. P. N. Chirvinsky (vol. 20, p. 287).

4. International agreement in mineralogical and crystallographical nomenclature: by Dr. L. J. Spencer (vol. 20, p. 353).

EXCERPT MINUTES OF COUNCIL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., March 17, 1925, at 4.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

The death of Prof. G. Murgoci, an Ordinary Member, was announced.

Mr. Alpheus Fuller Williams and Mr. Ivan Sidney Double were provisionally elected Ordinary Members of the Society.

It was decided to publish an index to vol. 2 of the Abstracts for the three years 1923-5 in the same form as the index to vol. 1, with a similar topographical index; and also an index to vols. 11-20 of the Journal for the thirty-one years 1895-1925.

The future of the Library of the Society was discussed, and a committee consisting of the Librarian (Prof. Lewis), Dr. Hutchinson, Dr. Prior, Mr. Campbell Smith, and Dr. Spencer was appointed to consider the matter and to report.

GENERAL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., March 17, 1925, at 5.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

Eighteen Members and seven Visitors were present.

The elections of Mr. A. F. Williams and Mr. I. S. Double were confirmed.

A demonstration, illustrated by models, was given by Sir William Bragg on the twinning of quartz crystals.

The following papers were read:—

1. The structure of aragonite: by Mr. S. Tomkeieff (vol. 20, p. 408).

2. The structure of pentaerythritol tetranitrate: by Dr. I. E. Knaggs (vol. 20, p. 346).

3. Potash-oligoclase from Mt. Erebus, Antarctic, and anorthoclase from Mt. Kenya, East Africa: by Mr. E. D. Mountain (vol. 20, p. 331).
 4. Further notes on the association of lime with other oxides of the RO-type in minerals: by Dr. A. Brammall.
 5. Crystallographic data of some new organic compounds: by Mr. Gilbert Greenwood (vol. 20, p. 393).
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EXCERPT MINUTES OF COUNCIL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., June 16, 1925, at 4.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

The following were provisionally elected Ordinary Members of the Society: Dr. Robert Campbell, Dr. Hardy Vincent Ellsworth, Mr. Aubrey Evelyn Horn, Mr. Robert Angus Alister Johnston, Dr. James Malcolm Maclaren, Dr. Patrick Marshall, Mr. William Elgin Swinton, and Prof. Ellis Thomson.

The following changes in the list of Officers and Council were approved for recommendation to the Members of the Society: Vice-President—Sir Thomas Holland in place of Dr. H. H. Thomas; Ordinary Members of Council—Prof. P. G. H. Boswell, Mr. T. Crook, Mr. L. Hawkes, and Dr. H. H. Thomas, in place of the four retiring Members of Council, Dr. Brammall, Mr. De Castro, Mr. Edge, and Sir Thomas Holland.

It was decided to hold four meetings next year on the following dates: Tuesdays, January 19, March 16, June 15, and November 2.

The Library Committee reported that a preliminary sorting had been made of books and periodicals to be retained and those to be discarded. It was proposed to keep all of purely mineralogical interest including separate copies of mineralogical papers, and also for the present all periodicals which are still being received. Of those to be discarded the Geological Society should be allowed the first selection of any which might be useful for completing sets, &c., and afterwards the Sedgwick Museum and other Libraries in Cambridge. The residue should be sold to booksellers who were to be invited to make offers for it, and the proceeds were to be devoted to the upkeep of the Library. The Committee was given power to act in accordance with these proposals.

GENERAL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., June 16, 1925, at 5.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

Twenty-one Members and four Visitors were present.

The elections as Ordinary Members of the Society of Messrs. Campbell, Ellsworth, Horn, Johnston, Maclaren, Marshall, Swinton, and Thomson were confirmed.

The dates of meeting for 1926 were announced.

The following papers were read :—

1. The use of the stereographic protractor for the interpretation of Laue crystal-photographs: by Dr. A. Hutchinson (p. 10).
2. The use of alinement charts in crystal-optics: by Dr. A. Hutchinson (vol. 20, p. 441).
3. The crystal-structures of the sulphides of mercury: by Messrs. H. E. Buckley and W. S. Vernon (vol. 20, p. 382).
4. Albite and other authigenic minerals in limestone from Bengal: by Dr. Edmondson Spencer (vol. 20, p. 365).
5. Chlorophaeite in the dolerites (tholeiites) of Dalmahoy and Kaimes Hills, Edinburgh: by Dr. R. Campbell and Mr. J. W. Lunn (vol. 20, p. 435).
6. Tenth list of new mineral names; with an index of authors: by Dr. L. J. Spencer (vol. 20, p. 444).

Specimens and models were exhibited by the authors in illustration of their papers.

EXCERPT MINUTES OF COUNCIL MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., November 3, 1925, at 4.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

Dr. Arthur Richard Derryhouse, Mr. Arthur Douglas Lumb, Dr. Edmondson Spencer, Prof. Aladár Vendl, and Prof. Miklós Vendl were provisionally elected Ordinary Members of the Society.

Mr. J. P. De Castro and Mr. A. F. Hallimond were appointed Auditors of the accounts for the year ending December 31, 1925.

A letter from the Royal Society was read announcing the grant of £100 from the Government Publication Fund towards the cost of publication of Mineralogical Abstracts.

The Editor reported that the December number of the Journal was in hand and would consist of indexes to vol. 20 of the Magazine and vol. 2 of the Abstracts, for which some 15,000 slips had been written.

The Library Committee presented a detailed report with lists of periodicals, &c. that had been disposed of, these apparently containing no matter of mineralogical or crystallographical interest. Certain presentations of small broken sets had been made on behalf of the Society to the libraries of the Geological Society of London, the Sedgwick Museum of Geology at Cambridge, the Cambridge School of Geography, and the Cambridge Philosophical Society. The remainder disposed of realized a sum of £55. The next task of the Committee will be to decide how best this fund may be employed for completing gaps in the set of periodicals retained and in binding some of the more useful and important. [The Society's Library has been housed in the Mineralogical Museum at Cambridge since 1890.]

Dr. A. Hutchinson was appointed Librarian in place of Prof. Lewis.

A Committee consisting of the President, Treasurer, General Secretary, Foreign Secretary, Editor, Dr. Hutchinson, Sir Henry Miers, Mr. Campbell Smith, Dr. Herbert Smith, and Dr. Thomas was appointed to consider how the Jubilee of the Society next year should be celebrated.

GENERAL (ANNIVERSARY) MEETING.

*Held in the Apartments of the Geological Society, Burlington House,
London, W., November 3, 1925, at 5.30 p.m.*

Prof. W. W. WATTS, F.R.S., President, in the Chair.

Twenty-one Members and seven Visitors were present.

The Chairman nominated Messrs. Garnett and Grantham to act as scrutineers of the voting-papers for the election of Officers and Council. The scrutineers reported that thirty-seven voting-papers had been returned to the Secretary, and that the list as nominated by the Council was approved, namely :—

President. Prof. W. W. Watts, Sc.D., LL.D., F.R.S.

Vice-Presidents. Prof. Harold Hilton, M.A., D.Sc.

Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc.,
F.R.S.

Treasurer. F. N. Ashcroft, M.A., F.G.S., F.C.S.

General Secretary. G. T. Prior, M.A., D.Sc., F.R.S.

Foreign Secretary. J. W. Evans, C.B.E., D.Sc., LL.B., F.R.S.

Editor of the Journal. L. J. Spencer, M.A., Sc.D., F.R.S.

Ordinary Members of Council.

Arthur Russell, M.B.E.	W. Campbell Smith, M.C., M.A., F.G.S.
H. Gladstone Smith, B.Sc., F.G.S.	C. E. Tilley, Ph.D., A.I.C., F.G.S.
T. V. Barker, M.A., B.Sc., F.C.S.	Prof. P. G. H. Boswell, O.B.E. D.Sc., F.G.S.
Sir William H. Bragg, K.B.E., M.A., D.Sc., F.R.S.	T. Crook, F.G.S.
A. F. Hallimond, M.A., F.G.S.	L. Hawkes, M.Sc., F.G.S.
J. A. Howe, O.B.E., B.Sc., F.G.S.	H. H. Thomas, M.A., Sc.D., F.G.S.

The elections as Ordinary Members of the Society of Dr. A. R. Derryhouse, Mr. A. D. Lumb, Dr. E. Spencer, Prof. Aladár Vendl, and Prof. Miklós Vendl were confirmed.

A vote of thanks to the Geological Society for permission to meet in the Apartments of the Society was carried.

The General Secretary then read the following ANNUAL REPORT OF COUNCIL.

During the Session 1924-5 four ordinary meetings have been held (by kind permission) in the Apartments of the Geological Society, Burlington House, W., at which twenty papers were read.

Four numbers of the Journal (nos. 107-110), containing twenty papers and 703 abstracts, have been issued quarterly. In no. 110 the blocks for Plates VII and VIII were lent by Dr. Hutchinson.

A Committee was appointed to consider the state of the Society's Library, and in accordance with its recommendations the books retained in the Library have been reduced to those of purely mineralogical interest including separate copies of mineralogical papers and also, for the present, all periodicals which are still being received by presentation or exchange. Of the books discarded, some were presented to the Geological Society of London, the Sedgwick Museum of Geology, the Cambridge Philosophical Society, and the Cambridge School of Geography, and the residue was sold. The proceeds of the sale are to be devoted to the upkeep of the Library.

The contributed papers and discussion of the joint meeting of the Faraday, Geological, and Mineralogical Societies on the physical chemistry of igneous rocks has been published, and is available to Members of the Society at a reduced price.

The balance-sheet for the year ending December 31, 1924, showed that the financial position of the Society was satisfactory. The assets (exclusive of the Library and stock of the publications) amounted to £1,404 7s. 3½d., with no liabilities. The value of the Stock invested in the names of the Trustees of the Society was on that date £1,112 17s. 6d., corresponding to £24 3s. 1d. for each Life-Member. A sum of £100 was granted by the Royal Society from the Government Publication Fund in aid of the publication of 'Mineralogical Abstracts'.

During the Session the Society has lost by resignation two Ordinary Members, by removal for non-payment of subscriptions two Ordinary Members, and by death four, namely: Sir Archibald Geikie, one of the original members of the Society; Prof. G. D. Liveing, one of the members of the Crystallological Society;

[Continued on p. xxxiv.]

MINERALOGICAL

ABSTRACT OF RECEIPTS AND PAYMENTS

		RECEIPTS.			GENERAL PUR-		
		£ s. d.			£ s. d.		
By Balance brought forward from 1924—							
1. At Bankers :							
(a)	Current Account	31	4	6			
(b)	Deposit Account	100	0	0			
2.	In Office	2	3	7			
					133	8	1
Annual Subscriptions—							
1.	Current year	113	4	0			
2.	Advance	10	10	0			
3.	Arrears	40	19	0			
					164	13	0
Entrance Fees ¹					22	1	0
Composition Fees					47	5	0
Sale of Publications—							
1. During 1924 :							
(a)	By Publishers (£179 15s. 6d. less trade discount £29 19s. 3d. and Commission £18 14s. 6d.)	181	1	9			
(b)	By Custodian of Stock (Balance due)	2	0	0			
2. During 1925 :							
	By Custodian of Stock (£27 5s. 0d. less trade discount £0 5s. 0d. and distribution charges £1 12s. 9d.) ²	25	7	3			
					158	9	0
Interest on Investments—							
1.	£1,050 5% War Loan Inscribed Stock ³	51	5	0			
2.	£50 5% National War Bonds 1927 Registered ⁴	2	10	0			
3.	£50 4% Funding Loan Inscribed Stock	2	0	0			
					55	15	0
Deposit Interest					8	19	8
Government Publication Grant administered by the Royal Society					100	0	0
					£690	10	9

¹ Includes five overdue fees.² Includes one payment in advance³ Includes investment made during the year.⁴ Incorrectly termed 'inscribed' in accounts for 1924.

SOCIETY.

FOR THE YEAR ENDING DECEMBER 31, 1925.

POSES ACCOUNT.

PAYMENTS.		£	s.	d.	£	s.	d.
To Printing and distributing the Mineralogical Magazine Nos. 108-111 inclusive (Oxford University Press), 1925—							
1. Printing		363	4	9			
2. Illustrations		22	4	3			
3. Authors' Copies		26	10	3			
4. Distribution Charges		12	16	6			
					424	15	9
Printing and distributing notices of Meetings and other miscellaneous printing, 1925							
					16	19	0
Expenses at Meetings—							
1. During 1924 :							
Proportion due under guarantee of expenses of joint Meeting with the Faraday and Geological Societies		3	7	8			
2. During 1925 :							
(a) Operator of the lantern		2	2	0			
(b) Porter		1	0	0			
					6	9	8
Care of the Stock of Publications, 1925 (J. Mugford)					1	1	0
Editor's Honorarium, 1925					25	0	0
Postage, &c., 1925—							
1. Hon. Secretary		14	0				
2. Editor		2	2	10			
3. Hon. Treasurer (not charged)					2	16	10
Renewal of Stock of Stationery					3	18	0
Bank charges, cheque book, and other small items					15	1	
Investment of Composition Fees, Purchase of £50 5% War Loan Inscribed Stock, Commission and Stamp					50	6	9
Balance, December 31, 1925—							
1. At Bankers :							
(a) Current account		42	7	4			
(b) Deposit account		115	0	0			
2. In Office		1	1	4			
					158	8	8
					£690	10	9

Examined and compared with vouchers and found correct.

J. PAUL DE CASTRO } Auditors.
A. F. HALLIMOND }

F. N. ASHCROFT, Hon. Treasurer.

January 16, 1926

LIBRARY FUND

RECEIPTS.

	£	s.	d.
By Sale of surplus books and periodicals	55	0	0
Deposit Interest		5	6

£55 5 6

BALANCE

DECEMBER

LIABILITIES.

£ s. d.

Excess of assets over liabilities	1541	19	8
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£1541 19 8

ACCOUNT.

PAYMENTS.

	£	s.	d.
To Binding of Periodicals	1	19	0
Balance, December 31, 1925—			
At Bankers :			
(a) Current Account	3	6	6
(b) Deposit Account	50	0	0
	53	6	6
	£55	5	6

Examined and compared with vouchers and found correct.

J. PAUL DE CASTRO } Auditors.
A. F. HALLIMOND }
F. N. ASHCROFT, Hon. Treasurer.

January 16, 1926.

SHEET.

31, 1925.

	ASSETS.	£	s.	d.	£	s.	d.
Balances—							
I. General Purposes Account :							
1. At Bankers :							
(a) Current account		42	7	4			
(b) Deposit account		115	0	0			
2. In Office		1	1	4			
					158	8	8
II. Library Fund Account :							
At Bankers :							
(a) Current Account		3	6	6			
(b) Deposit Account		50	0	0			
					53	6	6
Sale of Publications—							
By Publishers during 1925 (since paid)					159	5	3
Investments at Broker's Valuation—							
1. £1,050 5% War Loan Inscribed Stock at 101 $\frac{3}{4}$		1067	1	3			
2. £50 5% National War Bonds 1927 Registered ¹ at 105 $\frac{1}{4}$		52	12	6			
3. £50 4% Funding Loan Inscribed Stock at 85 $\frac{1}{4}$		42	17	6			
					1162	11	3
Arrears of Annual Subscriptions, valued at					8	8	0
					£1541	19	8

¹ Incorrectly termed 'inscribed' in Balance Sheet for December 31, 1924.

The stock of Publications and the value of the Library are not included in the above assets.

January 16, 1926.

F. N. ASHCROFT, Hon. Treasurer.

Prof. G. Murgoci and Mr. R. C. Webb; and the name of one Life-Member, Mr. Louis Wills, of whom for many years all trace has been lost, has been removed from the List of Members. Fifteen Ordinary Members have been elected. The total number of members on November 2, 1925, was 186, of whom twelve are Honorary. Of the Ordinary Members 46 are Life-Members.

During the Session Dr. Prior has continued to represent the Society on the Federal Council of Pure and Applied Chemistry, and Dr. Spencer and Dr. Herbert Smith on the 'Publications' and 'Miscellaneous' Committees respectively of the Imperial Mineral Resources Bureau.

The Council has to congratulate the Society on its continued scientific activity and prosperity.

On the motion of Dr. Herbert Smith, seconded by Mr. Tully, the Report was adopted.

The following papers were then read:—

1. The dissociation of dolomite: by Mr. C. S. Garnett (p. 21).
2. A new refractometer: by Mr. B. J. Tully.
3. New British occurrences of alstonite and barytocalcite: by Mr. Arthur Russell.
4. The meteoric iron of Vaalburg and meteoric stones of Witklip and Queens Mercy, South Africa: by Dr. G. T. Prior.

The new refractometer was exhibited by Mr. Tully, and specimens by Mr. Russell and Dr. Prior in illustration of their papers.

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 112.

March, 1926.

Vol. XXI.

*The construction and use of an X-ray goniometer.
Crystal-structure of glyoxaline compounds.*

(With Plate I.)

By GILBERT GREENWOOD, M.Sc.

Late John Harling Fellow in the University of Manchester.

[Read January 19, 1926.]

IN ordinary circumstances crystal-angles are measured by means of light reflected from the crystal-faces. In the partial or complete absence of faces the determination of axial ratios and angles may be impossible. In a recent investigation¹ of certain derivatives of glyoxaline, an example of this was found. It was, in fact, the substance glyoxaline itself, which always occurred as long prisms having four faces in the prism-zone; the ends of the prisms were jagged and rough, and no signs of optically reflecting-planes could be found on these ends. In such a case, X-ray methods of investigation are now available, and the problem in question is the determination of the dimensions of the unit-cell, not the complete X-ray investigation of the structure. Many substances, which do not exist in a suitable state for measurement by the crystallographer, have been investigated and the unit-cell

¹ G. Greenwood, *Min. Mag.*, 1925, vol. 20, p. 393.

determined, even if the exact atomic arrangement has not been found. Among such substances are to be found crystalline organic powders, metallic crystals, either in the form of conglomerate masses or wires, and also solidified gases like ethane. The photographic and ionization spectrometric methods, the powder photograph, and the rotating crystal method have all been used. In this paper the point of view is that of one who has generally worked with the ordinary goniometer rather than that of the X-ray analyst.

The object has been to build a somewhat composite goniometer in which the source of light is replaced by a source of X-rays, and the telescope by an ionization chamber, and to test such an instrument for ease and convenience of working. It was found when a zone was adjusted on the goniometer that the spacings of many faces in this zone could be rapidly determined, and thus the instrument also provides a good method of fixing the space-group of a crystalline substance, by a method of the spectrometric type. The new apparatus is shown in the photograph (Plate I). The graduated upper circle is fixed to a brass rod which carries at its lower end an adjusting goniometer-head of the usual type. Thus when the crystal is rotated, the graduated circle also moves and the reading is made against a fixed vernier. The lower graduated circle is just as in the older forms of X-ray spectrometer and the ionization chamber moves round this circle. In making the initial adjustments it is, of course, essential to bring the axes of rotation of the two scales into coincidence. This was achieved by setting pins exactly in the axes of rotation of both scales by means of a telescope. The upper scale was now moved about slightly until the tips of the pins when viewed in the telescope were exactly in the same vertical line. On the lower brass disc arrangements were made for the temporary mounting of two brackets carrying a telescope and a collimator. These were adjusted so that their optical axes meet in the axis of rotation of the two graduated circles and also lie in a plane perpendicular to it. In this way, in conjunction with the upper scale, they form a goniometer. Thus a small crystal can be mounted and adjusted on the instrument with all the rapidity of the ordinary goniometer. The slow-motion tangent-screws are in the form of a worm-thread working in a toothed groove which runs all round the graduated discs. In this way the same rotation of the screws always produces the same angular rotation of the circle. The tangent-screw of the upper circle bears a little pulley wheel which is driven by a large wheel above, which, in turn, is driven by a motor. By using suitably sized wheels and gearing arrangements it is possible to drive

the crystal round at the required rate. The field and armature of the motor are run on different circuits, thus by reversing the armature current it is possible to reverse the direction of rotation of the crystal. In this apparatus monochromatic Mo-radiation is used. It is generated by a Coolidge bulb, mounted on an adjustable holder, inside a large lead box. The bulb is run by means of a coil and a 'mercury-gas' break. The width and divergence of the X-ray beam is limited by means of two sets of slits, one close up against the lead box and the second as near to the crystal as possible.

In using the apparatus the crystal is mounted on wax on the holder and the zone-axis of the zone in question adjusted to be vertical by means of the telescope. It was found that an accurate adjustment can be made using the telescope alone without actually reflecting images of the collimator-slit. It is then very easy to find one of the large reflections from one of the more important faces in the zone, by sweeping the crystal in an appropriate position, and using the ionization chamber with its slits wide open. The exact crystal setting is then measured in the usual manner reflecting to the right-hand side. The chamber is then taken round to the same setting on the left-hand side, the reflection again found, and its position measured. In most cases quite small crystals—often only a few millimetres in size—are used. Under these circumstances, most of the reflection comes from the inner planes of the crystalline structure. This state of affairs is often further enhanced by the fact that the little crystals likely to be investigated are very transparent to X-rays. The result is that the effect of a badly cut surface mentioned by W. H. Bragg¹ does not come into play, and it is quite easy to recognize the two reflections as being the same. The mean of the two crystal settings gives the position of the normal to the crystal-face, with respect to the upper circle. A measurement of this sort may be made with any order of the reflections, e.g. the second order may be used if it is large or otherwise more convenient than the first. Another face is now examined in exactly the same way and the position of its face-normal measured on the upper graduated disc. The angle between these two settings is the ordinary interfacial angle of crystallography. A second type of angular measurement must now be made. This is the measurement of the glancing-angle. The procedure is essentially the same as in the X-ray spectrometers now in use. The chief point is to make sure that the true glancing-angle has been found, and that no intermediate spectra exist.

¹ W. H. Bragg, *Phil. Mag.*, 1914, ser. 6, vol. 27, p. 888.

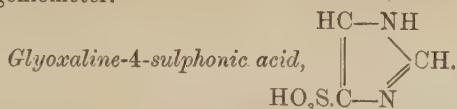
The first set of measurements when a sufficient number have been made serves to fix the axial ratios and axial angles. However, these axial ratios do not necessarily correspond to the true unit-cell, but may be this unit with one or more of its edges multiplied by a simple factor. The two sets of measurements taken in combination give means of finding this true unit. The easiest procedure is graphical—to make a drawing of the traces of the planes perpendicular to a plane containing two of the axes. In this way we can find the unit lengths along the axes which are consistent with the largest of the spacings measured for this zone. We may, and probably shall, find that a unit-cell of this size makes certain spacings multiples of that actually found. This is because the particular crystalline arrangement causes a halving, &c., of the true spacing. It is due to the presence of gliding-planes of symmetry, &c., in the structure, and this action has been well illustrated in a simple case by W. T. Astbury and K. Yardley.¹ Other zones and spacings must be considered in the same manner, and thus the three dimensions of the unit-cell can be definitely fixed and the spacial network is determined. The set of normal and divided spacings is dependent on the presence of glide-planes of symmetry, &c., and thus on the space-group. Very often a set of spacings is characteristic of a space-group, and thus the space-group of the particular structure can be found. Sometimes, however, a set of spacings is consistent with several-space-groups.

In determining the space-group the tables given by P. Niggli² or W. T. Astbury and K. Yardley may be used. A direct method is also useful. The perpendicular distance from the origin to any plane ($g\ h\ k$) passing through the points whose numerical co-ordinates are x, y, z , is given by $p = gx + hy + kz$, p also being in the numerical system and a unit value corresponding to the normal spacing of a unit-cell. Using the book of R. W. G. Wyckoff, 'The analytical expression of the results of the theory of space-groups' (1922), in which the numerical co-ordinates of all the points occurring in the space-group are given, we can easily determine whether a particular spacing is subdivided or not. Knowing the system, and sometimes even the crystal-class, we can often, even with quite a small number of spacings, determine which of the space-groups is concerned. This depends on the fact that the method is one of elimination.

¹ W. T. Astbury and K. Yardley, Phil. Trans. Roy. Soc. London, ser. A, 1924, vol. 224, p. 221.

² P. Niggli, Geometrische Kristallographie des Diskontinuums. 1919, p. 493.

The two substances described below have been investigated with the help of the new goniometer.



This substance, for which the apparatus was first used, has already been described crystallographically.¹ It was there found that the crystals are tetragonal, though they usually exhibit only the forms {001} and {110}. However, other very small facets were found, and from a consideration of these faces the crystal-class was stated to be ditetragonal alternating. This statement has now been absolutely confirmed, and the crystalline structure proved to belong to the space-group with Schoenflies's notation V_d^4 , which is a ditetragonal alternating one.

The following table gives the result of the search for spectra. All spectra are referred to the primitive translations of the unit-cell.

(110) absent	(100) absent	(230) present	(221) absent	(402) present	(001) absent
(220) present	(200) present	(130) present	(442) present	(603) absent	(002) present
(330) present	(300) absent	(260) trace	(663) absent	(102) present	(003) absent
(440) present	(400) present	(390) absent	(101) present	(204) absent	
(550) present	(140) present	(111) absent	(202) absent	(306) absent	
(660) present	(280) trace	(222) present	(303) absent	(203) present	
(770) trace	(103) present	(333) absent	(201) present	(406) absent	

The glancing-angles and interfacial angles measured as described above are shown in the following table. In the case of planes with 'halved spacings' the second order reflection was measured, from which has been calculated the corresponding first order for insertion in the table. The values agree with those calculated from a unit tetragonal cell of dimensions $a = 11.08 \text{ \AA.}$ and $c = 9.22 \text{ \AA.}$ These values give an axial ratio of 0.835, in good agreement with that crystallographically determined, viz. $c/a = 0.839$.

Plane.	Glancing-angles.		Angle.	Interfacial angles.		
	θ (mean).	θ (calc.).		Mean.	Calc	
(100) ...	1° 49'	1° 50'	(001) : (101) ...	39° 59'	39° 52'	
(110) ...	5° 12'	5° 12'	(001) : (201) ...	59° 14'	59° 6'	
(140) ...	7° 41'	7° 35'	(001) : (102) ...	22° 45'	22° 40'	
(230) ...	6° 43'	6° 38'	(001) : (203) ...	29° 1'	29° 1'	
(180) ...	5° 51'	5° 49'	(001) : (103) ...	15° 34'	15° 33'	
(001) ...	2° 11'	2° 12'	(100) : (110) ...	45° 6'	45° 0'	
(111) ...	3° 9'	3° 25'	(100) : (140) ...	75° 53'	75° 58'	
(221) ...	5° 52'	5° 40'	(100) : (230) ...	56° 15'	56° 19'	
(101) ...	2° 50'	2° 52'	(100) : (130) ...	71° 35'	71° 34'	
(201) ...	4° 17'	4° 17'	(001) : (111) ...	49° 25'	49° 45'	
(102) ...	4° 53'	4° 48'	(001) : (221) ...	66° 45'	67° 3'	
(203) ...	7° 36'	7° 34'				
(103) ...	6° 55'	6° 54'				

¹ G. Greenwood, Min. Mag., 1925, vol. 20, p. 397.

The density of the crystal was found to be 1.838, and calculation thus proves that there are eight molecules in the unit. An examination of the table of results shows that the following planes possess 'halved spacings': (100), (001), (111), and (221). By small calculations of the type described above we see that the space-groups in the ditetragonal alternating class which have the (100) spacing halved are all those from V_d^3 to V_d^{12} . Further calculation using the (230) planes shows that those which possess (100) halved and (230) normal, like the crystal

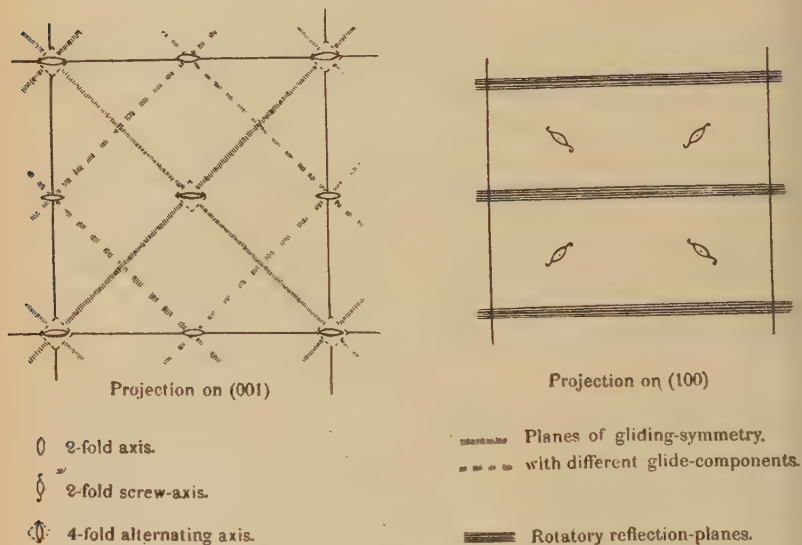


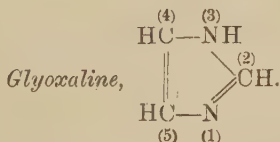
FIG. 1. Symmetry of the space-group V_d^4 of Glyoxaline-4-sulphonic acid.

in question, are only V_d^3 and V_d^4 . To decide between these two we may use the planes (001). And we find that the only group which gives (100) and (001) halved together with (230) normal is V_d^4 . Hence this is the space-group for the crystalline structure of glyoxaline-4-sulphonic acid. A similar result is obtained by using the tables of W. T. Astbury and K. Yardley,¹ where this space-group [D_{2h}^4] is described 'as having '{100}' halved', and '{h h l}' halved if l is odd'; all others being normal. The fact that eight molecules occur in the unit shows that the crystal-molecule must be completely asymmetric. Since in the previous determination of the crystal-class of this substance, the only evidence was

¹ loc. cit., p. 238.

the alternating occurrence of small facets, this point should be given further consideration. The whole of the other space-groups in the tetragonal system were examined and found not to give the required spacings, whatever the number of molecules in the cell. In those cases where the choice of crystal-axes was arbitrary—sometimes a rotation of 45° round the c -axis can be made, bringing (110) to (100), &c.—the alternative orientation was considered and found never to fit. It might be remarked that such a second orientation is not possible in the ditetragonal alternating class. This definitely fixes the crystal-class and the space-group.

The elements of symmetry of the space-group V_d^4 are shown in fig. 1, in which is represented a projection of the planes (001) and (100). There are planes of rotatory reflection parallel to (001), at a distance c/a apart. Parallel to the c -direction in the crystal are tetragonal axes of the second order passing through the vertical edges and middle of the cell, also digonal rotation-axes through the mid-points of the horizontal edges of the cell. The planes (110) are planes of gliding-symmetry; they are of two kinds, having different glide-components. There are digonal screw-axes parallel to [100] (and also [010]) at a distance $a/4$ and $c/4$ from the sides and base of the cell.

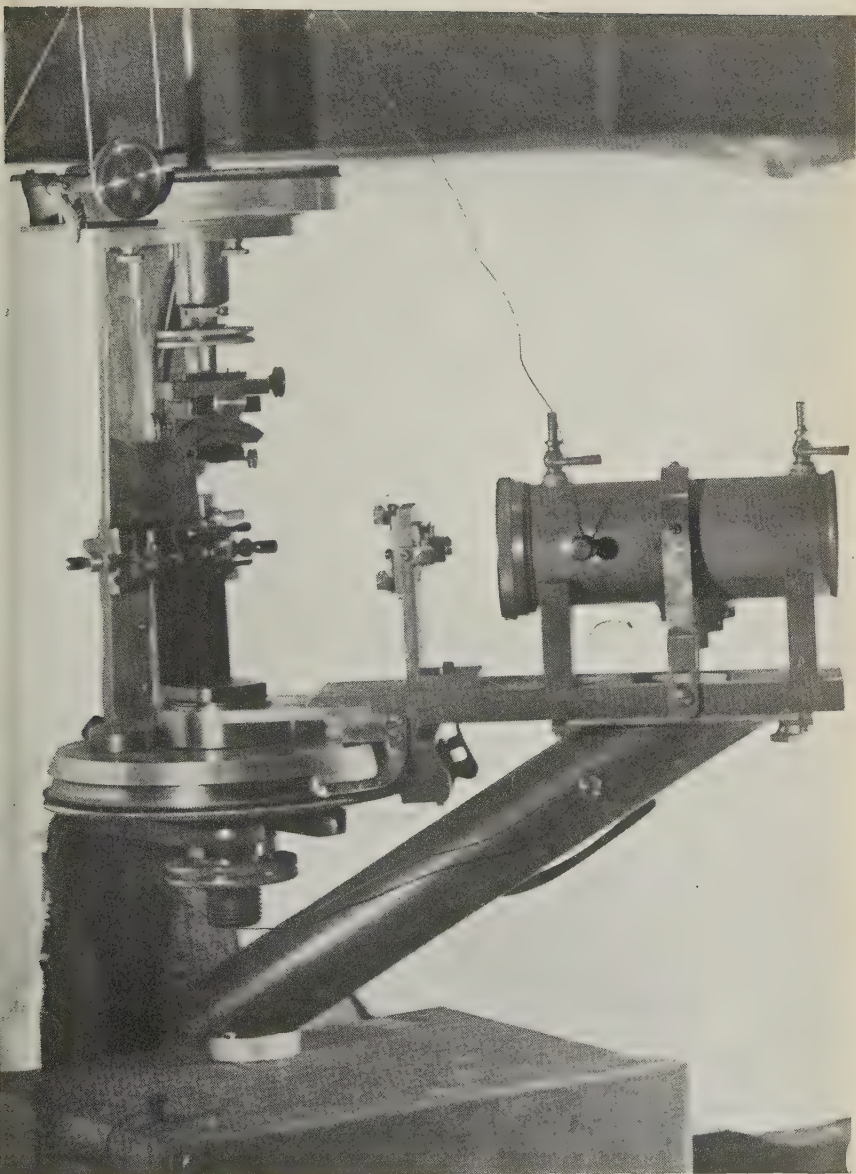


In the case of this substance the task was much more difficult. No crystallographic examination had been or could be made, since the crystals were always so unsatisfactory. Many attempts were made to grow crystals. The substance had a great tendency to crystallize as long and rather fibrous prisms, having no terminal faces. After experiments with many solvents it was found that the best crystals were obtained by crystallization from ether, and that the prismatic habit was most pronounced when grown from benzene solution. In this latter case, prisms 50 mm. in length and less than 1 mm. in thickness were usually obtained. The first zone to be investigated was the prism-zone. This zone was found to contain a face (100), together with prism-faces of the type $(h\ k\ 0)$ and $(h\ \bar{k}\ 0)$. This can only be explained by the crystal being orthorhombic or monoclinic. By suitable re-setting on the wax of the holder a second zone, containing again (100) and passing over the

broken ends of the crystal, was brought into position. No face could be found at right angles to the face (100). All the angles measured between the crystalline planes justified the reference of these planes to two axes obliquely inclined to each other, and lying in the plane at right angles to the zone-axis. By measuring the angle between two faces, one in each zone, it is possible to find the angle between the two zones. This was found, as expected, to be 90° . A stereographic projection of these zones and crystal-angles showed that the crystals are monoclinic. In the following table are recorded the glancing-angles and the crystal-angles, which lead to a unit monoclinic cell of dimensions $a = 7.67 \text{ \AA.}$, $b = 5.44 \text{ \AA.}$, $c = 5.12 \text{ \AA.}$, and $\beta = 63^\circ 11'$. This gives an axial ratio of $a:b:c = 1.411:1:0.942$. All the glancing-angles are found to agree with those calculated from this unit-cell, i.e. none of the spacings are halved.

Plane.	Glancing-angles.		Angle.	Interfacial angles.		
	θ (mean).	θ (calc.).		Mean.	Calc.	
(100) ...	$2^\circ 59'$	$2^\circ 58'$	(100) : (310) ...	$22^\circ 51'$	$22^\circ 45'$	
(110) ...	$4^\circ 47'$	$4^\circ 47'$	(100) : (210) ...	$32^\circ 24'$	$32^\circ 10'$	
(210) ...	$6^\circ 58'$	$7^\circ 2'$	(100) : (320) ...	$40^\circ 4'$	$39^\circ 59'$	
(120) ...	$8^\circ 5'$	$8^\circ 2'$	(100) : (110) ...	$51^\circ 31'$	$51^\circ 31'$	
(180) ...	$11^\circ 44'$	$11^\circ 42'$	(100) : (120) ...	$68^\circ 30'$	$68^\circ 20'$	
(310) ...	$9^\circ 39'$	$9^\circ 41'$	(100) : (130) ...	$75^\circ 16'$	$75^\circ 10'$	
(320) ...	$11^\circ 42'$	$11^\circ 42'$	(100) : (201) ...	$27^\circ 32'$	$27^\circ 29'$	
(201) ...	$9^\circ 8'$	$8^\circ 55'$	(100) : (101) ...	$39^\circ 4'$	$39^\circ 29'$	
(101) ...	$6^\circ 39'$	$6^\circ 23'$	(100) : (001) ...	$63^\circ 11'$	$63^\circ 11'$	
(001) ...	$4^\circ 28'$	$4^\circ 28'$	(100) : (102) ...	$80^\circ 56'$	$81^\circ 24'$	
(102) ...	$8^\circ 29'$	$8^\circ 2'$	(100) : (101) ...	$101^\circ 28'$	$101^\circ 28'$	
(101) ...	$4^\circ 14'$	$4^\circ 6'$	(100) : (201) ...	$132^\circ 43'$	$132^\circ 21'$	
(201) ...	$5^\circ 39'$	$5^\circ 36'$	(110) : (001) ...	$73^\circ 21'$	$73^\circ 42'$	

A determination of the density of glyoxaline was made and found to be 1.167. Calculation therefore shows that there are two molecules in the unit-cell. The fact that none of the spacings examined are halved proves that the space-group of the structure must be C_s^1 or C_2^1 or C_{2h}^1 . Each of these space-groups belongs to a different class of the monoclinic system, and it is thus in this case not possible to decide the crystal-class by means of X-ray measurements. Owing to the peculiarly bad manner in which the substance crystallizes it is also impossible to obtain any evidence on this point by the usual crystallographic methods. By considering from the space-group point of view the fact that there are two molecules in the unit, we see that if the crystal is holohedral, the glyoxaline molecule itself must possess an element of symmetry—a twofold



G. GREENWOOD : X-RAY GONIOMETER

digonal axis or a plane of symmetry—whilst if the crystal belongs to either of the two other classes, the molecule must be asymmetric. As ordinarily depicted (see p. 7) the molecule appears asymmetric, but it is a well-known and striking chemical fact that the same substance is obtained by substituting another group for the hydrogen in either the 4 or the 5 positions. Or, in other words, the two nitrogen atoms are quite identical, the hydrogen belonging equally to the two. In view of this fact it is easy to conceive the glyoxaline molecule as possessing a plane of symmetry. It therefore seems likely that the substance crystallizes in the holohedral class and that the space-group concerned is C_{2h}^1 . A description of the symmetry properties of the three space-groups concerned can be found in Niggli's book, pages 146, 150, and 153.

When this work was practically completed Professor F. L. Pyman and his assistants, who have most kindly supplied me with the crystals, were able to obtain rather better crystals of glyoxaline, which showed a face on the end of the prism. These crystals were only obtained once, and it has not been found possible to reproduce them. Using these crystals it was possible to make one or two goniometric measurements, the results of which are shown in the table.

Angle.		Optical goniometer measurement.		X-ray goniometer measurement.
(110) : ($\bar{1}$ 10)	...	76° 59'	...	76° 58'
(100) : (001)	...	63° 6'	...	63° 11'
(110) : (001)	...	73° 21'	...	73° 21'

Finally I wish to express my best thanks to Professor W. L. Bragg for his many helpful suggestions and advice during this work. I should also like to record my appreciation of the work of Mr. W. Reynolds of the Physics Department workshop, who constructed the actual instrument as well as supplying useful advice on certain practical details.

The use of the stereographic protractor for the interpretation of Laue crystal-photographs.

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[Read June 16, 1925.]

THE spots of a Laue crystal-photograph may be regarded as due to the reflection of X-radiation by the planes of the crystal and the interpretation of these photographs involves the determination of the index of the plane by which any given spot is produced. This interpretation can be readily accomplished by two distinct though related methods. We may, in the first place, utilize the stereographic projection and determine the indices of the planes by means of intersecting zone-circles. This method, the earliest in point of time, was explained by W. L. Bragg¹ in 1913. In recent years, however, it has become usual to employ for this purpose the gnomonic projection which affords a solution in some respects simpler and more direct than the stereographic method used by Bragg, and detailed illustrations of its application in this field have been given by R. W. G. Wyckoff,² and E. Schiebold.³

It is the object of this communication to show how the protractor described to the Society by the author⁴ in 1908 may be used with advantage for finding rapidly, and without calculation, the gnomonic projections of the planes producing the Laue spots.

The nature of the problem to be solved is readily seen from fig. 1, where XN represents the path of a narrow beam of X-rays passing through a crystal situated with its centre at O and impinging normally at N on a photographic plate RG . This beam causes the large intense

¹ W. L. Bragg, Proc. Roy. Soc. London, ser. A, 1913, vol. 89, p. 248.

² R. W. G. Wyckoff, Amer. Journ. Sci., 1920, ser. 4, vol. 50, p. 319. [Min. Abstr., vol. 1, p. 194.]

³ E. Schiebold, Die Naturwissenschaften, 1922, vol. 10, p. 399.

⁴ A. Hutchinson, Min. Mag., 1903, vol. 15, pp. 93-112.

central spot of the Laue photograph. Part of the X-radiation is reflected to R by a crystal plane PP' , passing through O normal to the paper, and making an angle $P'OX = \theta$ with the incident beam. OG drawn perpendicular to PP' gives the gnomonic projection at G of the plane to which the spot produced at R is due. If ON , the distance of the centre of the crystal to the photographic plate, and NR , the distance between the centres of the central spot and the spot R , are measured, the angle 2θ can be found from a table of tangents and the distance NG can then readily be calculated, for $NG \div NO = \tan(90^\circ - \theta)$.

It has been pointed out by Wyckoff and also by Schiebold that time and trouble can be saved if a standard distance is adopted for ON (distance from crystal to the photographic plate) and a table is constructed

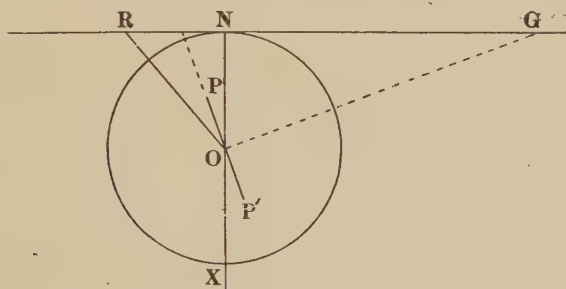


FIG. 1. Gnomonic projection of X-ray reflection.

giving corresponding values of NR and NG . Such tables have been prepared by Wyckoff (loc. cit.) for $ON = 3, 4$, and 5 cm. Further, Wyckoff has found it convenient to solve the problem graphically by employing rulers bearing graduations corresponding to the tabular distances mentioned above. Fig. 2 represents one of Wyckoff's rulers, the finer graduations of the original having been omitted. The short arm is graduated in centimetres subdivided to millimetres and numbered from $0-7$. On the long arm, at distances taken from the appropriate table, are placed graduations which give the gnomonic projection of the plane producing a Laue spot, the distance of which from the centre is read on the short arm. If the ruler is placed on the Laue photograph with its zero-point C on the middle of the central spot, the gnomonic projection of the plane causing a spot lying opposite division 2 (say) on the short arm is found opposite division 2 on the long arm.

The stereographic protractor for a sphere of radius 5 cm, described by the author in 1908 can be used for this determination in a precisely

similar way, the distance from crystal to the photographic plate being 5 cm. The zero-point *O* of the protractor shown in fig. 3 (the finer graduations of the original have been omitted) is placed on the middle of the central spot and the position of a Laue spot read on the lower scale of the short arm *OS*. This reading, divided by four, gives the position, as read on the lower scale of the long arm *OT*, of the gnomonic projection of the plane producing the spot. Thus, if a Laue spot is opposite 60° as read on the lower scale of the short arm, the projection

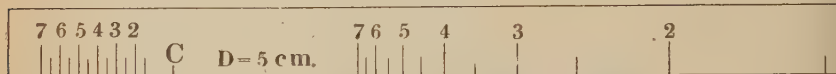


FIG. 2. Wyckoff's ruler for Laue photographs.

of the corresponding plane is found opposite 15° read on the lower scale of the long arm.

Since, however, the protractor as made for students' use, and intended especially for the construction of stereographic projections, is too short for finding the gnomonic projections of planes lying at large angles from the centre of the projection, the author has had some protractors specially constructed of greater length. These protractors are made exactly in the

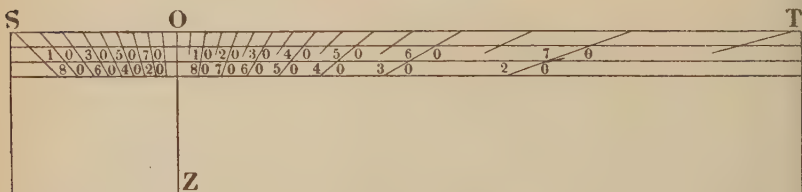


FIG. 3. Hutchinson's stereographic protractor.

same way as those previously described, that is to say, a long strip of boxwood or celluloid 5 cm. in width is adjusted so that a point in one edge about 9 cm. from one end coincides with the centre of a circular dividing engine. The opposite edge is then graduated in degrees. The strip is then turned round and the opposite edge graduated in the same way. The scales are then appropriately numbered. In the new protractors the scales on one edge are numbered exactly as heretofore, that is to say, as shown in fig. 3. These scales are used for making stereographic and gnomonic projections and for measuring angles between projected planes and zones as described in 1908 (*loc. cit.*, p. 100 et seq.).

To make the instrument more conveniently applicable to the interpretation of Laue photographs the numbering of the scales on the other edge has been slightly modified, as shown diagrammatically in fig. 4, the finer graduations being omitted. Thus, as regards the scale on the long arm, only the lower row of numbers extending from 30° to 7° is given, and as the portion of the scale from the zero-line to 30° is not required, it has been omitted. Similarly, as regards the short arm, only the lower row of numbers of fig. 3 is given but the scale has been extended, and to obviate the necessity of dividing by four, the numbering is so arranged that an angle of twenty degrees as graduated is numbered ten degrees. Now, since in fig. 3 twenty degrees as graduated is numbered forty degrees on the short arm, the new numbering is equivalent to dividing by four the scale-reading on the short arm of the protractor shown in

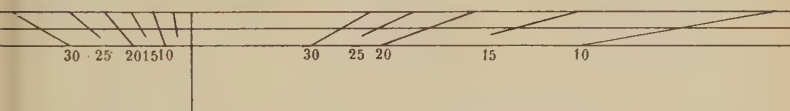


Fig. 4. Hutchinson's scale for Laue photographs.

fig. 3. From this it follows that a Laue spot and the gnomonic projection of the plane causing it have identical scale-readings on opposite sides of zero on the short and long arms respectively. A further and important advantage of this method of numbering is that the scale-reading of a Laue spot gives directly the value of θ , the glancing-angle at which the X-rays strike the plane producing the spot. The sine of this angle can then be taken from the tables without further calculation.

The reason for adopting the numbering described above becomes evident on comparing the scales with fig. 1. The graduations on the long arm are at distances proportional to $\tan(90^\circ - \theta)$. The distance of the Laue spot is proportional to $\tan 2\theta$. By assigning to any graduation on the short arm a number of half its real value in degrees the position of the gnomonic projection of the plane inclined at the glancing-angle θ has the same numerical value.

As the protractors can be graduated to a sufficient degree of accuracy on a circular dividing engine with but little attention on the part of the operator, they can be produced at a minimum amount of trouble and expense. They can be obtained from Mr. W. H. Harling, 117 Moorgate, London, E.C. 2.

Gold and silver in the Dartmoor granite.

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[Read January 19, 1926.]

Introduction.

GOLD and silver have been detected not only in the peculiar facies of the granite occurring on Bittleford Down,¹ but also in the normal grey biotite-granite of numerous tor- and quarry-localities; several hand-specimens of granite showing minute flakes of visible gold have been collected.

The modes of occurrence of gold on Dartmoor, the environment of the granite from which specimens showing visible gold have been taken, and the gold-silver content of the granite generally have been investigated in some detail, with the results described below.

Occurrences of gold and silver.

Previous to the identification of gold and silver in the Bittleford pegmatite, detrital gold had been identified in only four out of about 120 samples of stream-sand and 'head' examined at an early stage of this work. Though the number of samples which have yielded gold now totals seven, the total yield of the metal from such samples is only a few milligrams.

In following up this identification, considerable attention was paid to vein-quartz, blocks of which may be met with on the surface of the moor along almost every traverse. Minute specks of gold have been detected in only two of the numerous blocks broken up and examined on the ground. The following occurrences, however, deserve mention.

On a well-developed crystal of vein-quartz collected a few years ago

¹ A. Brammall and H. F. Harwood, The occurrence of a gold-bearing pegmatite on Dartmoor. *Min. Mag.*, 1924, vol. 20, pp. 201-211.

by Miss I. M. McCrea (late of Newnham College) somewhere in the vicinity of the Vittifer mines and acquired by the author, the latter observed several minute flakes of gold embedded in patches of earthy haematite coating the specimen. The exact source of this crystal has not been traced, though the author and his colleagues Dr. H. F. Harwood and Mr. J. G. C. Leech have made a thorough search of the locality.

In a water-clear crystal of cavity-quartz found by Mr. P. G. Stevens on the top of North Hessary Tor, the finder detected several minute inclusions which he identified as particles of gold, this identification being confirmed by the author.

A scrutiny of 'heavy mineral' concentrates from fresh crushed granites was more fruitful. Though gold was detected in only three samples of normal tor-granite, minute particles of it were identified in concentrates from several specimens of the Bittleford pegmatite. The occurrence at this locality has already been described.¹ Assays of representative samples of the pegmatite and of the sulphidic ore-grains extracted from the rock revealed the constant presence of both gold and silver (see table on page 19).

Visible gold has been noted in several hand-specimens of normal grey biotite-granite. Two occurrences, in east and west Dartmoor respectively, are here described.

Welstor Cross quarry, near Buckland Beacon, east Dartmoor.--This quarry is traversed by several veins of compact granular quartz striking nearly east-west and dipping north (at 35° – 42°), these directions agreeing with the strike and dip respectively of one of the main joint-systems developed at this locality. The main quartz-vein is about 8 inches thick; the others are much thinner. The thickest vein shows occasional nests of radiating tourmaline and isolated patches of felspar. No vughs have been observed. It may be regarded as an extreme (leucocratic) modification of the granite. No visible gold has yet been detected in this vein-quartz.

Minute film-like flakes of gold forming an aggregate visible to the naked eye (see fig. 1, p. 16) were found on the fracture-surface of a large block of the normal granite taken by the author from a bench about 4 feet above the main quartz-vein. This fracture-surface is highly irregular; it exposes fresh granite quite free from iron-staining, oxides of manganese, and other secondary minerals, and cannot reasonably be regarded as a joint-plane. The flakes (up to 1.2 millimetres long) shown

¹ loc. cit.

in fig. 1 lie on a fracture-surface across plagioclase. They are curiously fluted, the direction of fluting being approximately parallel to the out-crops of twin-lamellae discernible with difficulty. The interior of the block was explored in the laboratory by breaking up the specimen between the jaws of a rock-crusher. Similar clusters of still more minute flakes were detected on two of the fragments so obtained. These clusters occur about the margins of, and also on, orthoclase phenocrysts which are only feebly discoloured by iron-staining. A few flakes are intimately associated with minute patches of limonitic material doubt-



FIG. 1. Showing fluted film-like flakes of gold in plagioclase exposed on the fracture-surface of a granite specimen from Welstor Cross quarry. The largest flake is about 1.2 millimetres long. The direction of fluting appears to be closely related to the strike of the twin-lamellae. (Flakes drawn by Dr. O. M. B. Bulman).

less representing altered iron sulphide gossan on a small scale. Only two blocks showing visible gold were found at this quarry during the course of several visits occupying in all about ten hours. An assay of representative material collected indiscriminately from the quarry revealed only a minute trace of gold and silver.

Small quarry near cottage immediately south of Vixen Tor, west Dartmoor.—The joints at this locality include a nearly vertical system striking west-south-west and apparently related to a quarry-face of pneumatolysed granite and to thin erratic quartz-schorn stringers. Pneumatolytic effects extend also along narrow zones below, and roughly parallel to, the quarry-benches. The quarried rock is fresh grey

biotite-granite apparently quite normal. Visible gold was first detected in a specimen of this granite by Mr. P. G. Stevens. After a prolonged search by him and the author jointly, five similar specimens were found.

On the first specimen taken, numerous minute flakes of gold are visible with the aid of a pocket-lens. Two of the flakes are definitely embedded in groundmass quartz; others lie along or across the cleavage-planes of felspar. A few only are associated with microscopic crusts of iron oxide. The surfaces carrying these flakes are highly irregular and unlikely to be related to any of the joints affecting the quarried rock.

On other specimens, most of the flakes are intimately associated with gossan-like crusts of iron oxide.

Representative material collected indiscriminately at the quarry was assayed, the values found, per long ton (2,240 lb.), being 6.3 grains (0.00004 %) of gold and 38.1 grains (0.00024 %) of silver.

Evidence in favour of the primary character of the gold and silver.

The possibility that the gold at the Vixen Tor locality may have been introduced into the granite by processes incidental to local pneumatolysis was tested by an assay of a fair sample of the reddened pneumatolysed granite flanking the quarry-benches. The assay yielded not even a trace of gold, and only 8.8 grains of silver per ton (0.00005 %).

The frequent association of minute flakes of gold with iron oxide suggested the desirability of assaying the iron sulphide present in the granite. The content of sulphide, however, was too small to justify the cost of materials necessary to separate it from the crushed rock in quantity adequate for an assay.

On the other hand, minute crystals of pyrites separated from the granite of the Prison quarry, Princetown, are identical in habit with the pyrites occurring as well-formed interpenetrant pyritohedra (up to $\frac{1}{2}$ inch in diameter) in a matrix of decomposed and haematite-stained granite forming a zone of 'bad rock' in the Merrivale quarry. The latter occurrence of vein-pyrites is almost certainly syngenetic with the Princetown granite, which, however, differs considerably from the Merrivale and Vixen Tor facies. The vein-pyrites yielded on assay (per ton) only 1.6 grains (0.00001 %) of gold, but 125.3 grains (0.0008 %) of silver.

If this gold value is not considerably exceeded by that of the pyrites in the granite of the Vixen Tor quarry, it seems improbable that altering pyrites can be the sole, or even the main, source of the visible gold in this granite. As certain of the joint-planes at this locality carry manganese-rich dendrites, sometimes associated with arsenopyrite, autunite, haematite, and schorl, a typical sample of manganese-incrustation taken at the Merrivale quarry was assayed: it yielded (per ton) 9.6 grains (0.00006 %) of gold and 72.7 grains (0.00046 %) of silver. On the other hand, an assay of the Merrivale granite itself yielded (per ton) 3.6 grains (0.00002 %) of gold and 106.2 grains (0.00067 %) of silver. These figures afford no ground for assuming that the gold and silver found in the granite were introduced by waters circulating in the joint-planes. The converse—that the gold and silver present in the joint-plane incrustation were extracted from the granite—is at least possible.

Following the identification of two minute particles of gold in mounted 'heavy mineral' concentrates from the Princetown granite, this rock was assayed, and yielded (per ton) 6.0 grains (0.00003 %) of gold and 156.8 grains (0.001 %) of silver.

On the basis of values ascertained for the Merrivale vein-pyrites, the figures for the Princetown granite are perplexing, unless other constituent minerals besides pyrites carry gold and silver. A thorough examination of numerous samples of the Princetown granite failed to detect a single flake of gold in association with either the quartz or the feldspar. There remained therefore the biotite. About 40 grams of biotite were separated from the granite and assayed: the values found (per ton) were only 1.5 grains (0.000007 %) of gold, but 108 grains (0.00069 %) of silver.

A calculation based on the content of biotite and pyrites in the granite showed either that the pyrites was much richer in gold and silver than the Merrivale vein-pyrites, or that the major constituents, quartz and feldspar, also enclosed finely divided particles of the metals. The quarry occurrences of visible gold described on pages 15–17 render the latter alternative highly probable.

That both metals are primary and indigenous to the granite is further suggested by the results of assays of tor- and quarry-granites from other parts of the moor. The assay-results as a whole are given in the following table, which incorporates the values for the Bittleford pegmatite and also the results of assays of St. Austell granites kindly communicated to the author by his colleague Mr. J. G. C. Leech.

Assay-values for gold and silver in granites.

						Gold.	Silver.
<i>Dartmoor Granites:</i>						(Grains per ton of 2,240 lb.)	
Normal tor-granites: ²							
Birch Tor	...	...	...	...	...	nil	20.4
Bonehill Rocks	...	...	...	...	...	2.4	1.2
Greater Rocks	...	...	...	...	...	1.2	9.6
Northcombe, Widecombe	...	...	...	...	...	1.2	54.0
Normal quarry-granites: ²							
Cold East Cross quarry	...	...	...	...	...	1.6	10.4
Haytor: east quarry	...	...	...	...	...	trace	6.0
Haytor: west quarry	...	...	...	...	...	1.2	6.0
Merrivale quarry	...	...	...	...	...	3.6	106.2
Princetown: Prison quarry	...	...	...	...	...	6.0	156.8
Vixen Tor quarry	...	...	...	...	...	6.3	38.1
Welstor Cross quarry	...	...	...	...	...	trace	trace
Miscellaneous: ²							
Biotite, Princetown granite	...	...	...	...	...	1.5	108.0
Graphic granite, Hameldown	...	...	...	...	...	trace	9.6
Pegmatite, Ponsworthy	...	...	...	...	...	trace	16.8
Pneumatolysed (red) granite, Vixen Tor quarry	...	...	...	...	...	nil	8.8
Manganese-rich deposits on joint-planes,							
Merrivale quarry	...	...	...	...	...	9.6	72.7
Vein-pyrites, Merrivale quarry	...	...	...	...	...	1.5	125.3
						218.4	360.0
						156.0	33.6
						129.6	264.0
						93.6	55.2
						33.6	14.4
Bittleford Pegmatite ³						21.6	170.4
						16.8	40.8
						14.4	187.2
						12.0	16.8
						9.6	26.4
						7.2	28.8
<i>St. Austell Granites:</i> ²							
China-stone	...	...	...	...	...	1.0	97.4
Colcerrow type	...	...	...	...	...	4.8	56.6
Prideaux type	...	...	...	...	...	2.4	27.8
						1.6	120.0
<i>Californian Granites</i> ⁴						2.1	19.1
						1.8	14.7
<i>Nevadan Granite</i> ⁴						17.7	87.6

¹ Note: 24 grains per ton (2,240 lb.) = 1,530 milligrams per metric ton.² Assayed by C. W. Dannatt, Lecturer, Royal School of Mines, who reported also that in each case the cupel showed a slight green stain indicating traces of copper.³ Assayed by B. W. Holman, Assistant-Professor, Royal School of Mines.⁴ Cited by F. W. Clarke, Data of Geochemistry, 1911, pp. 613-614.

Conclusions.

From the occurrence of visible gold as inclusions in both quartz and felspar, and from the presence of both gold and silver (the latter in quite appreciable quantity) in biotite, the primary character of the two metals may be reasonably inferred.

The closest examination of vein-quartz, and the assays of vein-pyrites, incrustations on joints, and pneumatolysed rock, afford no grounds for attributing the gold-silver content of the granite either to the diffusion of siliceous or other solutions, or to the production of pyritous veins, or to processes incidental to pneumatolysis.

On the other hand, the occurrences described and the numerous assays made of apparently barren granites support the conclusion that both metals are intimately associated with both the earlier and the later products of crystallization from the granitic magma direct, and that they are primary.

Numerous occurrences of primary gold in granite are on record.¹ A. Lacroix quotes C. F. Lincoln (1911) in respect of fifteen such occurrences, and describes the occurrence of the metal in pegmatite. G. P. Merrill observed gold embedded in the quartz and felspar of a Mexican (Sonora) granite. The Dartmoor occurrences are closely comparable to those described by L. Wagoner for three Californian and one Nevadan granite. Wagoner's assay-figures are appended to the table given on p. 19.

The author's thanks are due to Professor W. W. Watts for kind advice and for laboratory facilities provided in the Geology Department of the Imperial College; to Dr. H. F. Harwood, Mr. J. G. C. Leech, and Mr. P. G. Stevens for valuable assistance in the field; and to the Department of Scientific and Industrial Research for a grant in aid of the general investigation of the Dartmoor granite.

¹ For references to literature, see *Min. Mag.*, 1924, vol. 20, p. 210, and F. W. Clarke's *Data of Geochemistry*.

The dissociation of dolomite. II.

By CECIL S. GARNETT, F.C.S., F.G.S.

[Read November 3, 1925.]

IN this paper further evidence is put forward in support of a previous paper on the subject.¹ Very soon after the reading of that paper, A. E. Mitchell² read a paper before the Chemical Society on a closely related subject. Working quite independently, and employing other methods of investigation, Mitchell arrived at conclusions in close agreement with those detailed in the former paper. H. L. J. Bäckström³ has criticized Mitchell's paper, raising some objections 'against the experimental evidence produced and the . . . way of interpreting it'. Where Bäckström's objections touch on anything in Mitchell's paper which is incidentally akin to any of the work described in this or the earlier paper, they will be discussed herein. Thus, Bäckström states that Marc and Šimek⁴ found that, in the presence of water-vapour as a catalyst, magnesite suffered dissociation at a lower temperature than otherwise. In the method of experiment adopted by the present writer, the air which was constantly aspirated through the substance under examination was previously washed by being passed through a solution of potassium hydrate, and it would therefore contain much water-vapour. Bäckström, in support of his statement that 'It has been known for a number of years that the dissociation of dolomite takes place in two steps', merely cites K. Friedrich and L. G. Smith, and states that 'Grünberg⁵ showed that the amount of carbon dioxide given off in the first step corresponds exactly to the amount of magnesium present in the dolomite'.

N. V. S. Knibbs,⁶ however, cites the work of J. B. Shaw and G. A. Bole,⁷ who concluded that there are three different kinds of dolomite: one in which the dolomite dissociates as a whole; another in which the magnesium carbonate dissociates separately; and a third, a mixture of

¹ C. S. Garnett, *The dissociation of dolomite*. *Min. Mag.*, 1923, vol. 20, pp. 54-59.

² A. E. Mitchell, *Journ. Chem. Soc. London*, 1923, vol. 123, p. 1055.

³ H. L. J. Bäckström, *Journ. Chem. Soc. London*, 1924, vol. 125, p. 430.

⁴ R. Marc and A. Šimek, *Zeits. Anorg. Chem.*, 1913, vol. 82, p. 17.

⁵ K. Grünberg, *Zeits. Anorg. Chem.*, 1913, vol. 80, p. 337.

⁶ N. V. S. Knibbs, *Lime and magnesia*. London, 1924, p. 82.

⁷ J. B. Shaw & G. A. Bole, *Journ. Amer. Ceram. Soc.*, 1922, vol. 5, pp. 311, 317

the other two. C. H. Desch¹ states that dolomite ignited 'so as to decompose the magnesium carbonate while leaving the calcium carbonate unchanged, yields a product which sets with water'; also, that several patents have, from time to time, been taken out in many countries for the production of cements, artificial stones, &c., from dolomite by heating it so as to yield a mixture of magnesia (MgO) and calcium carbonate, which, after being mixed with water, will set hard.

Subsequent to the writing of the former paper, in which it was contended that the dissociation of dolomite does not proceed in two distinct stages, of which the first is represented by the equation $\text{CaCO}_3 \cdot \text{MgCO}_3 \rightarrow \text{CaCO}_3 + \text{MgO} + \text{CO}_2$, and in order to secure further evidence, the setting properties of such a mixture as the semi-burning was supposed to produce were tested. Magnesia and precipitated chalk ($\text{MgO} + \text{CaCO}_3$) in equal molecular proportions were mixed and made to a paste by the addition of water and allowed to stand at room temperatures; contrary to what might be expected from the cited statement of Desch and the patents, this did not set even in a small degree, and when the water had dried out there was not any cohesion between the particles.

Other mixtures were then tried, in order, if possible, to determine the true cause of the setting, and whether it is in agreement with the single-step dissociation theory. Magnesium carbonate ('magnesia alba') and dry slaked lime in equal molecular proportions, similarly treated, set decidedly and quickly. In this case, setting has resulted from a chemical reaction, and it will be noted that the mixture is the reverse of that which was supposed to set, but actually did not do so. Dry slaked lime was similarly tried with ground raw dolomite; also with calcite; and both these mixtures exhibited the ordinary and normal slow set of lime.

Magnesite gave the somewhat surprising result of behaving merely as the dolomite and calcite mixtures, and thus quite distinct from 'magnesia alba'. The marked difference between the dissociation temperatures of the native and prepared carbonates of magnesium was noted in the previous paper, and distinct difference in constitution now seems to be clearly indicated. It may be noted here that this observation is clearly quite neutral towards the question of the process of the dissociation of the dolomite molecule.

The peculiar setting properties of semi-burnt dolomite are lost when the material becomes stale, a condition which can be detected by the fact that no slaking and rise in temperature takes place on the addition of a suitable amount of water. This, again, would seem to indicate that

¹ C. H. Desch, *The chemistry and testing of cement*. London, 1911, p. 57.

the setting properties are connected with free lime in the intimately associated mixture of oxides, and, evidently, inert substance; and such is borne out by the fact that a similar setting mixture can be made by mixing, in suitable proportions, finely ground quicklime with dry slaked lime and a practically inert substance such as clean sand. Such a mixture, after being made to a paste with water, can be moulded and sets almost identically as the semi-burnt dolomite.

Thus, the setting properties of dolomite, calcined to the correct degree, appear to be due to hydration of free lime, and not to a mixture of magnesia and calcium carbonate. The single-step dissociation theory is thus in accordance with the facts of setting, but these are contrary to the two-step one.

During the investigations of the present author, a phenomenon has been noticed which, for some time, was perplexing. The process of formation of dolomite must undoubtedly be an exothermic reaction, yet under some conditions of dissociation a marked evolution of heat was noticed—accompanied by a bright incandescent glow in the rock, which is quite distinct from the ordinary red-heat glow of the same material after the reaction has passed. When dolomite was heated (as described in previous paper) in the iron vessel, and the gas adjusted, at the commencement of the heating, to raise the temperature to a little over 800°C . and the millivoltmeter watched, it was noticed that the needle would rise steadily and then, whilst the heating remained constant, the temperature would fall several degrees before it became stationary. This observation was made repeatedly; and, more recently, the writer has observed the phenomenon of the incandescent glow, accompanied by a rapid rise in temperature, which was not due to firing, in a mass of about two tons of rock which was being very carefully calcined in a commercial kiln.

The explanation offered is that whilst the temperature of the rock is rising at sufficient speed and the evolved carbon dioxide allowed to escape very freely, the dissociation proceeds smoothly as a single step, but when further dissociation becomes very slow or tends to cease, then a reaction takes place between free lime (CaO) present and the equilibrium proportion of magnesium carbonate remaining in the dolomite. From the setting tests it was found that lime and magnesium carbonate (when the latter was in suitable form) would react together in the presence of water at ordinary temperatures, and from the comparative affinities of lime and magnesia for carbon dioxide it is to be expected that such a reaction would take place at the noted temperatures. Moreover, the heat of formation of calcium carbonate is sufficiently in excess of that (or the

heat of dissociation) of magnesium carbonate, plus that of dolomite from the single carbonates, to account for the described phenomenon of heat evolution, the magnitude of which will be dependent on the temperature to which the rock is steadily raised and on the rate of heating ; as, if it is done very slowly, the reaction between the lime and carbonate may be expected to accompany closely the dissociation. This reaction, in its most simple form, may be represented by : $\text{CaO} + \text{MgCO}_3 \rightarrow \text{CaCO}_3 + \text{MgO}$, but it is probably really $\text{CaO} + \text{CaCO}_3 \cdot \text{MgCO}_3 \rightarrow 2\text{CaCO}_3 + \text{MgO}$.

Thus, the composition of the residue from the heating of dolomite will not reveal the process of its dissociation, and Bäckström's contention that a pressure-composition curve would indicate the process of dissociation is clearly at fault ; such a curve would be governed by the equilibrium products resulting from a reaction quite subsequent to actual dissociation of the original compound.

After the publication of the former paper, and during the course of the further work on the subject, a distinct improvement in the method of investigation (described in that paper) was evolved. It was realized that, although the results obtained led to conclusions which were being confirmed from other considerations (and were themselves subsequently found to be good), yet the procedure of heating the stone to a certain temperature and then determining the carbon dioxide content of the residue (as was done in the case of the higher temperatures) was not an entirely sound method. The vital part of the experiment, from the point of view of the question of the process of dissociation, was, however, free from the objection ; but, in later work, the whole curve was substantially confirmed by conducting the entire range of dissociation in a fused silica flask and weighing the carbon dioxide evolved exactly as was done in the lower range of dissociation. By working on a small weight of rock, all the evolved carbon dioxide was easily absorbed and determined.

In view of the knowledge which we now possess of the course of the dissociation of dolomite, the author's method for its investigation would appear to be the most decisive for such an examination of similar substances. The principle of the method is the continuous thorough removal from the reaction vessel of the carbon dioxide as it is evolved during dissociation, and its accurate measurement at any and every desired moment. It may be noted that, as quite distinct from the behaviour of dolomite, when examined by this method, a mechanical mixture of magnesite and calcite is readily seen to be such, each dissociating in its own range and with a distinct break in the carbon dioxide evolution curve.

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